ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 - - TELEPHONE: TEMPLE BAR 3663

Vol. 184 No. 4790 *LONDON, FRIDAY, DECEMBER 27, 1957* PRICE 2s.

CALIBRATION OF AN OXYGEN ANALYSER

Nurnberg photograph for ENGINEERING

DECEMBER 27, 1957 VOL. 184 PAGES 801-832

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Published every Friday by Engineering Limited, 35 & 36 Bedford-street, London, W.C.2.
TELEPHONE: *Temple Bar* 3663. TELEGRAPHIC ADDRESS: *Engineering Lesquare London.*
Subscription Rates: 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s.*; 3 *months*, 27*s.* 6*d.* *all countries.* *Single copies*, 2*s.* 7*d.*, *post free.*

TRICKY CYCLES

LIFE for the individual to-day is not a steady flowing stream. Personal affairs, social affairs, industrial affairs and political affairs move in cycles. There are fashions even in engineering and science, and the change inherent in a cycle of events acts both as a stimulant and as a brake. As a stimulant, change may be welcomed; as a brake it may compel us to move too slowly, so that we feel that some things could be done quicker than they are.

When Sir Robert Watson-Watt was posted to meteorological work at the beginning of the First World War, he was set on that course of painstaking inquiry into thunderstorms which eventually led to the development of radar. Even before the worst follies of fighting had been committed in that static, brute-force war, a young man was working on seemingly rather remote things which, engineered into another form, were to play a vital part in a later, more dynamic war. If there is any lesson to be derived from that aspect of the development of radar, it is simply that some of the best developments of science and engineering could never be planned, that some freedom of inquisitiveness is essential, even if it is supported by more deliberate planning in fields which seem to require co-ordination and allocation of resources.

Because engineering is creative it is specially affected by the cyclic pattern of men and their activities. Creative ability, in the engineering sense, demands the power to perceive new relationships, to look at the same set of facts and circumstances that have been looked at many times before, but to notice that their relative values have changed since they were last looked at; and, because of that change, to see that new possibilities are opened up. This power of perception is bound up with the cyclic background of our lives. There are, in fact, several cycles—the day, the week, the year, the decade and the generation. If we can understand their effect on the individual, we are on the way to making good use of them. The key may lie in recognising and distinguishing between the human, social cycles which we can to some extent control, and those physical, universal cycles which are beyond our power to control.

Look at the longest first—the generation. Most of the major developments of engineering spring from this time cycle. A man is taught by teachers of the previous generation. His way of looking at things is conditioned by his parents and his teachers, but fortunately he does not see things quite as his elders intended him to. If he has creative ability he does in fact see some odd things, and, seeing them, he is spurred to inquire into them. And if he thus concentrates on something really big, he may spend the whole of his life on work which has a continuous thread, even though at the beginning he is utterly in the dark about the end.

It is not necessary to be an inventor (the word has a quaint Victorian flavour), to pursue a vocation in this single-minded way. Every worth-while—and many despicable—endeavours can be practised as a life-long pursuit. To the man himself, however, the years are likely to fall into a pattern of decades. Someone has said that from twenty to thirty a man is serving his apprenticeship; from thirty to forty he should know where he is going and press hard to get there; from forty to fifty he will make his greatest contribution, and presumably get the greatest reward; and from fifty onwards—then everything depends on whether he is an ordinary man or an exceptional character or, indeed, a lucky fellow. It would be easy to point to cases which have not followed this cycle, but such a pattern is typical of the majority, and it is a useful guide early in life.

There are some people—notably economists—who plan as much as ten or fifteen years ahead. But for most of us the year is a convenient span to consider, both personally and in our professional functions. It is long enough as a basis for thought to raise fairly fundamental issues, which can be weighed in the mind, acted upon and tested within a reasonable time; yet it is not so short as to admit of only trivial matters.

Admittedly, these are abstract concepts. Maybe half of the most successful men have never consciously been aware of them. But if the examination of other people's lives has any value it must reveal this cyclical element. To the individual, it is an aspect of his life which is partly under his control. He may even influence the cycles that are inherent in the corporate lives of groups of people. In this way he can practise the art of enabling ordinary people to do extraordinary things. It is in that kind of relationship—the power of a man to influence others and the receptiveness of a man to ideas thrown out by others—that engineering has the greatest power for good. And if that sounds like Nineteenth Century altruism, then it is nevertheless probably appropriate to 1957 and 1958, because while we are scoffing at the 1920's and 1930's, we are beginning to realise that the Victorians were not the fools we thought they were. The fact that we are now recognising it is yet another example of the cycles in our lives.

Cover Picture. *The measurement of oxygen content in industrial gases is becoming increasingly important, enabling plant to be maintained at high efficiency. For example, the oxygen content in flue gases is a more fundamental index of combustion efficiency than carbon dioxide content. The illustration shows an oxygen analyser being adjusted during calibration. The type of analyser shown depends for its operation on the fact that oxygen, unlike most gases, is paramagnetic, that is, it is attracted into a strong magnetic field.*

* * *

Plain Words

As is well known to students of American life, the average American working in his office on the fifty-ninth floor experiences at mid-morning a certain restlessness. He rises from his chair, takes the elevator and, arriving at street level, proceeds to the tobacco kiosk in the foyer, where he buys a cigar. After a brief chat with the kiosk girl, he returns to his office feeling refreshed and relaxed. Mid-morning tea or coffee serve a similar purpose in this country, except, sadly, there is no kiosk girl. Unfortunately, when the tea, coffee or cigar is through, the average American or Englishman tends to glance at his watch and discovers that it is only an hour or so to lunch: no time to start anything now; what is more, he has lost the momentum to continue what he was doing before.

In this respect the Russians, too, are quite human; they may take their tea black and with lemon but the principle is much the same. They even have a word for it, *khalatnost*—the dressing-gown attitude, which means roughly: if you can't make up your mind what to do next, don't do anything. The French, too, nod occasionally; wasn't it one of the less transient French prime ministers who suggested that the working week begin on Tuesday, since he could never get started on a Monday?

In Britain, at least, this human weakness reaches new dimensions about this time of year. Almost any request or suggestion is met by the counter-proposal that whatever it is can surely wait until after Christmas. By the time this issue appears, some will be recommending a similar postponement until the New Year. Any excuse is good enough for a celebration, and also for putting something off—like those who communicate with their friends by scribbling "be writing soon" on Christmas cards, and find each successive Christmas that they have failed to do so. If the lost time is counted up in dyspeptic man-hours, it probably amounts to quite a few cigars, cups of coffee or what have you.

If we could only train our minds to make full use of even the briefest intervals between calls, snacks, interruptions and public festivals, and to pick up a job just where we left off without a long period of mental re-accommodation, we should all be able to work a three-day week. A scheme of training would of course call for strong self-discipline and determined application. The New Year —or even Lent—might be a good time to start.

ASTRONAUTIC SYSTEMS

The Conquest of Space

The illustration opposite is reproduced from a handsome coloured wall-chart produced by the Convair Division of the General Dynamics Corporation, San Diego, California, in which the company "attempt a definition of objectives in the achievement of manned space flight." We give below the main points of Convair's survey and explanation of the chart; the latter, it will be observed, was compiled before the launching of the Sputniks, and of Convair's own intercontinental ballistic offspring, the Atlas missile, which may itself be destined to play some part in the research satellite programme. If plotted on the chart, Sputnik II at apogee would be above Vanguard on the satellite curve, at about 10^3 miles altitude.

The probable main steps in man's conquest of space are: (1) Exploration of the outer fringe of the terrestrial atmosphere by manned orbital vehicles, capable of making several revolutions around the Earth before drag-loads compel a landing. The major objectives would be twofold: the adaptation of men and machines to the high ascending accelerations necessary to attain operating altitude, and the gathering of data about man's existence in the space environment. (2) At considerable altitudes above the Earth's atmosphere, satellites—permanent manned space stations—will serve firstly as space laboratories, later as launching bases for further exploration of space by other vehicles. (3) Operations in Earth-Moon space for exploration of our nearest celestial neighbour: such explorations would enable us to get the "feel" of space. (4) Interplanetary flight. (5) In the far distant future, perhaps, interstellar and intergalactic flight.

On the chart, reproduced opposite, distances to targets are expressed logarithmically in nautical miles on the vertical scales at the extreme left and right of the chart. Distances between planets are expressed according to flight path (orbit to orbit) rather than between planetary surfaces or centres. The horizontal scale at the bottom of the chart defines the energies required for the respective missions, expressed in terms of velocities that must be imparted to a vehicle, in thousands of feet per second.

On the right side of the chart, distances are bracketed by the propulsion systems that, on the basis of present technology, appear likely to be practical for these various regions of space. Symbolically, these propulsion systems are pictured in the adjacent column. The vehicles are not drawn to relative scale.

Regions of space, indicated on the left side of the chart, are defined according to predominating physical characteristics. Their arbitrary limits are understood to reflect not sharp changes but a gradual merging of one region into the next. It should be noted that because the planets are placed logarithmically on the grid, Uranus and Neptune have been omitted from the chart, as they would lie close between Saturn and Pluto.

Beyond Earth's atmosphere is *Terrestrial* space, ranging roughly to one earth-radius altitude (3,444 nautical miles), where terrestrial magnetic and electric influences are still comparatively strong. In *Cislunar* (this side of the Moon) space, the Earth's gravitational influence decreases, while simultaneously the Moon's influence increases, until, in *Lunar* space, orbits are dominated by the Moon's gravitational field. In *Translunar* space (beyond the Moon), the combined gravitational attraction of Earth and Moon is still the predominating influence on a space vehicle. But at about 500,000 nautical miles the Sun becomes the dominating centre of attraction and therewith we enter the vast realm of *Interplanetary* space, in which are imbedded the various planetary spaces. Within the Sun's gravitational field, each of the target planets creates a local gravitational pocket (as does Earth) that overrides the Sun's influence as we approach that planet. In interplanetary space, each planet thus becomes a perturbative force as a space vehicle nears it. Far beyond the planet Pluto, the solar *g*-field becomes insignificant, and *Interstellar* space begins. Finally, beyond our galaxy stretches the starless void of the Intergalactic region.

The velocities on the horizontal scale are expressed as "ideal" velocities. If all the energy of the propulsion system were used to propel the vehicle, the vehicle could attain ideal velocity in flight. However, part of the total energy is used to overcome gravity and atmospheric drag (if any). Thus, the vehicle attains an actual velocity somewhat less than ideal velocity. The velocities on the abscissa are the sum total of the minimum ideal velocities required for all manœuvres during a round trip from the Earth to the target planet and back.

For manned orbital gliders, the ideal velocity is the energy required to attain altitude and make the desired number of revolutions before the vehicle falls back to Earth. For permanent satellites, the ideal velocity is that required to reach and remain in the satellite orbit. Once orbital velocity is attained, propulsive force is no longer needed, since there is no atmospheric drag at this altitude. In the remoter interplanetary objectives, ideal velocity is computed as that required to go from an orbit 300 nautical miles above Earth to a satellite orbit around the target planet. The energy levels given, then, are close to minimum.

In the propulsion range column at the right, the solid arrows indicate distances for which the various propulsion systems are applicable. The broken arrows show that a particular propulsion system could, theoretically, be extended to these respective distances, but it probably would not be practical. The propulsion systems are displayed according to energy sources—i.e., chemical combustion; atomic pile; electric arc heating (but not burning) of gases; electrical acceleration of ions; nuclear fusion; and finally, the conversion of matter into light (photonic system).

A measure of the effectiveness of the propulsion system is its specific impulse, defined as lb.-thrust obtained per lb. of medium expended per second. For the foregoing systems these values are:

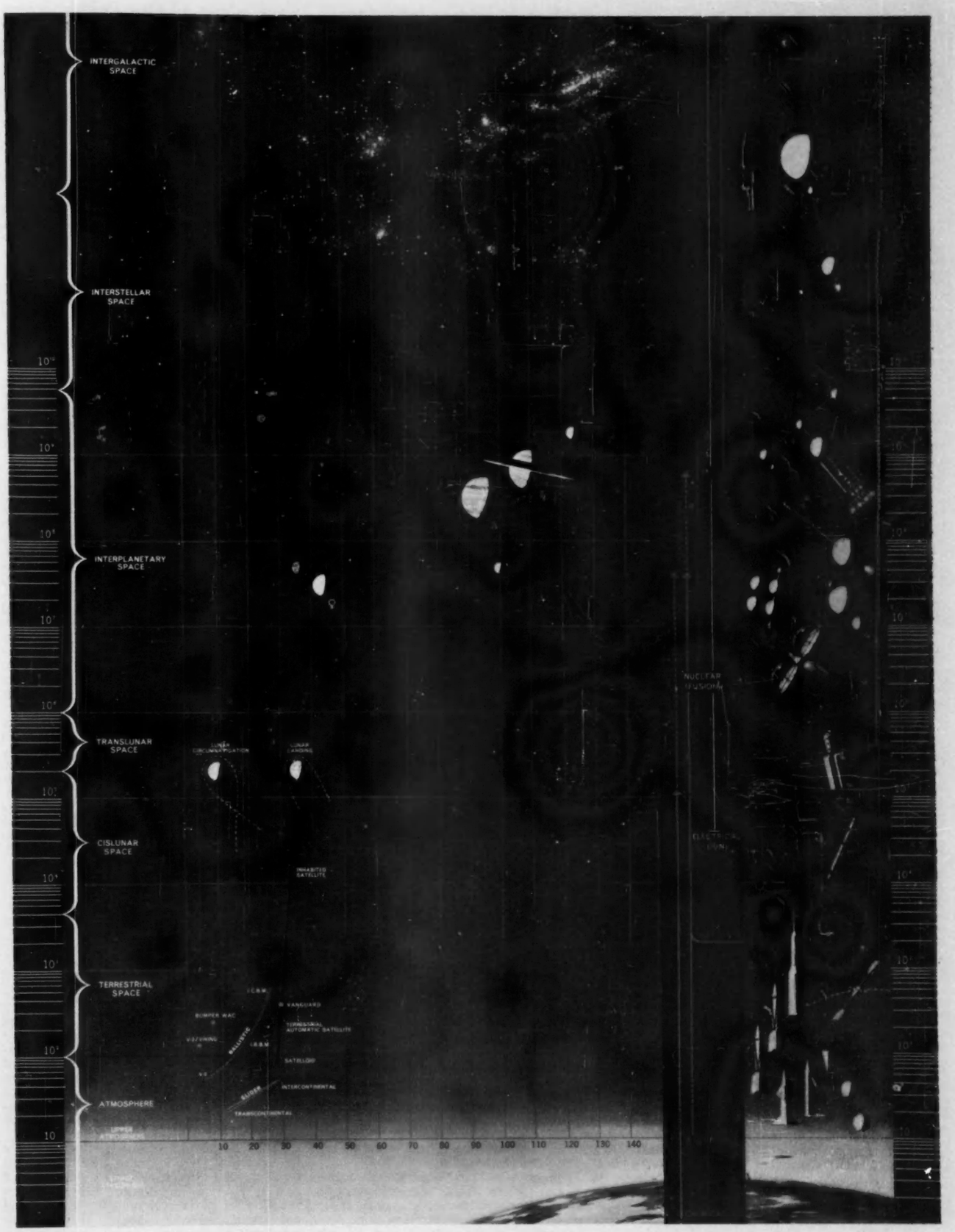
Chemical combustion	$\lesssim$ 400
Atomic pile	$\lesssim$ 800
Arc heating	$\approx$ 1,200
Ion acceleration	$\gtrsim$ 10,000
Nuclear fusion	600,000
Photon drive	38,400,000

There is thus a tremendous growth potential for space-vehicle propulsion systems, even if they cannot all be realised.

The probable changes in characteristic vehicle configurations with the advancements in space-vehicle propulsion systems and operational ranges are illustrated at the far right of the chart. At the lowest altitude is a hypersonic glider—a winged space vehicle designed to return to earth. Plotted on the lower orbit are various designs of instrumented satellite. The upper orbit shows a small paddle-shaped manned satellite.

To the left of the instrumented satellites are the winged (multistage) and ballistic rocket devices, representing manned passenger vehicles and automatic supply ships. Above them are drawn the V-2, the Bumper-WAC, and a hypothetical three-stage vehicle for high-altitude research.

The next two vehicles operate from orbits in



Ideal velocity, in 1,000 ft. per sec., to attain the flight distances shown.

Exploring space: the way to the stars.

Range of application of various propulsion systems.

Characteristic vehicle configurations for attaining distances shown.

Continuing Astronautic Systems

cislunar and lunar space, the lower vehicle representing a circumnavigational, the upper a lunar landing vehicle. Up to this point, only chemically-powered vehicles are indicated, although atomic-pile heating also could be employed. Apart from chemical or nuclear energy, solar energy is available, if properly concentrated by lightweight pressure-stabilised collectors, represented in the next vehicle as two connected spheres. Such a system, which may be propelled by an arc-heated jet, is shown operating in the inner solar system.

The capability of the chemical drive to operate in the space between Venus and Mars is indicated by the next two vehicles, the left one having jettisonable tanks of heavier propellants which are liquid at normal temperatures. The vehicle at the right would operate on high-performance liquefied gas propellant with large tanks of high volume-to-surface ratio.

Above these is pictured the more powerful nuclear vehicle, with its man-carrying gondola far removed from the hydrogen tank and atomic pile behind it. If the nuclear vehicle works only with pile-heated fluids, its range may be extended to Jupiter and Saturn, assuming that suitable frozen materials (e.g., ammonia or methane) can be found on some of their satellites to permit refuelling for return. If the vehicle operates on the basis of nuclear reaction (fusion), it has unlimited range across the solar system.

Unlimited interplanetary range also can be expected of the ion-driven vehicle portrayed next. Because it appears technically much more feasible to-day than a fusion drive, the ion drive represents the most attractive solution for a vehicle capable of visiting all planet systems.

The uppermost configuration represents a photon vehicle, driven by the pressure of light. Actually, this light would be invisible, since its wavelength would be in the X-ray and gamma-ray region.

Such a vehicle represents a state of technical and scientific accomplishment far beyond present capabilities. It could possibly be used for interstellar or, even more appropriately, for intergalactic travel. Its acceleration would be extremely low and it would take many generations of manned operators before the vehicle could attain velocities of a significant fraction of the speed of light. Therefore, whether ion, fusion or photon propulsion is chosen, the inhabitants would have to be prepared to propagate themselves through time as well as through space on their way to other stars.

Letters to the Editor

TRAIN COMFORT

SIR, Having belatedly read the article "Railway Modernisation—Carriages and Wagons" on page 540 of your issue of October 25, I was interested to learn that "an improved double-bolster bogie was evolved from the most satisfactory designs of the former main-line companies." The experience of one who migrated from the North-East to the West Country is that the standard British Railways corridor stock running between Bristol and Paddington is noticeably less comfortable than ex-London and North Eastern Railway stock; the difference consists of a lateral jerking movement with a frequency of the order of one cycle a second, which is absent in ex-L.N.E.R. stock and present, to the detriment of any reading or writing by passengers, in B.R. stock. I have noticed this difference in trains containing both types, thus eliminating possible differences in permanent way between different Regions.

In view of this observation (which is confirmed by other engineers and can easily be verified by any who feel inclined) it would be interesting to know what criterion was used in comparing the former designs and arriving at the present design.

Yours faithfully,
S. A. V. SWANSON.

Kington House,
Thornbury, Bristol.
December 13, 1957.

ELECTRICITY FROM OWEN FALLS

SIR, On page 682 of your issue of November 29, in the note headed "Jolt for Uganda," you say that the news—that is, the withdrawal of the interest of Calico Printers Association Limited from the Uganda textile industry—raises important questions for the future of the extensive Owen Falls hydro-electric scheme. You also say that "Nyanza Textiles is one of the Board's biggest customers" and that "any severe loss of revenue from Nyanza . . . must have immediate repercussions."

It is always regrettable when a company takes a step such as that taken by the Calico Printers Association, but it is important that the electrical angle should be put in its proper perspective. The Board's revenue for the first nine months of 1957 was approximately £814,000, of which Nyanza Textiles contributed just over £9,000, and, by 1965, when it is expected that the output from the Owen Falls scheme will be fully taken up, the revenue from Nyanza Textiles is estimated to be about 3 per cent. of the total.

When the second hydro-electric scheme on the Nile was under preliminary consideration about a year ago, the Board engaged the Economist Intelligence Unit to make an independent survey of the load potential, and in their report "Power in Uganda 1956-70," they suggested that the second dam should be commissioned by 1965, in spite of all the imponderables associated with the textile industry in Uganda which were fully discussed in that report. It is, of course, the hope of everyone in Uganda that the textile industry will flourish under the new régime and that the very conservative estimates of electricity consumption during the next decade will be substantially exceeded.

In the last paragraph of the note, referring to the Kilembe Copper Mine, you say that "work is also under way at Jinja on a smelter to process the ore mined at Kilembe." The smelter at Jinja has, in fact, been operating for just over a year and now takes nearly 6,000 kW of demand.

Yours faithfully,
W. D. D. FENTON,
Chairman.

Uganda Electricity Board,
P.O. Box 559, Kampala.
December 11, 1957.

COOLING TOWER PACKINGS

SIR, I have noted Mr. Derek J. Tow's remarks on page 676 of ENGINEERING for November 29 regarding my letter on cooling tower packings, printed on page 615 of your issue of November 15, and I should like to make the following comments:

(1) Despite Mr. Tow's remarks about capital costs with cooling towers fitted with extended-surface or film flow packings, it is a fact that they are marketed at prices competitive with towers fitted with splash-bar packings. It would not be unreasonable, therefore, to assume that, if my critic's reasoning is correct, it would apply that the purchaser of an extended surface packed tower would be obtaining better value for his money.

(2) For a duty to meet the normal industrial cooling requirements in this country, it is a fact that the use of extended-surface type packing would result in a tower with a lower inlet water height and a smaller plan area compared with a splashed packed tower.

(3) Drift eliminators are only required on towers fitted with film flow packings where the duty is so easy to obtain that water loadings of over 180 to 200 gallons per sq. ft. of plan area of packing are utilised with standard air flow rates.

(4) Engineers who have to operate and maintain cooling towers fitted with pipe-sprayer systems would confirm that these systems easily foul up and are not readily unchoked.

(5) Inspection of the middle part of the packing has always been a problem, but after 20 years' experience in inspecting all types of cooling-tower packings, I can say, with a certain amount of confidence, that it is possible to make a very fair appraisal of the general condition of the packing merely by examining the condition of the timbers at the top and bottom of the pack. To attempt to descend into the middle of a splash packing after, say, ten years' service, is courting disaster.

(6) The report mentioned by Mr. Tow on the deterioration of cooling-tower timbers dealt exclusively with splash packings. The problem of soft rot or Chaetomium attack has been solved by the use of suitable timber preservative treatment. It is purely wishful thinking on Mr. Tow's part to suggest that extended-surface packings will not enjoy the same life as splash packings under equal conditions.

His reference to happenings in the United States is irrelevant, as the design of extended-surface packing in the New World is still in its infancy, and the trouble to which he refers may well be the penalty of a lag in development—an American shortcoming not unknown in other spheres! I fully endorse Mr. Tow's comments regarding performance guarantees.

Mr. Tow's claim of a 30 per cent. to 40 per cent. saving for a 6 deg. F. approach instead of a 5 deg. F. approach, has led him unwittingly to expose the Achilles' heel of splash packings. A recent investigation, on behalf of a client interested in film packed towers, showed that, with a cooling range of 32 deg. F. it was only 16 per cent. cheaper to cool the circulating water to an 8 deg. F. approach of the wet-bulb temperature, as compared with an approach of 5 deg. F.

Yours faithfully,
E. A. HOWE.

Film Cooling Towers (1925) Limited,
Brentford.
December 13, 1957.

MORE STEEL OR BETTER CONCRETE

SIR, I read with interest the article on "More Steel or Better Concrete for Cheaper Designs: An Economic Approach to Reinforced Concrete," by Dr. J. R. Lawrence, in your issue of November 1 (page 564). I would like to point out, however, that there appears to be a fallacy in the arguments put forward, due to the combining of concrete and shuttering costs into an overall cost per unit volume of concrete.

Let us consider, for instance, a beam with a total depth of twice its width. By reducing its depth a small amount we reduce the shuttered area by a certain proportion. This proportion is four-fifths of the corresponding proportional decrease in volume of concrete. If the breadth is reduced instead of the depth, then the ratio is only one-fifth.

With the present-day price of timber and labour, the cost of shuttering, with its associated

stemming and scaffolding, is often five times the cost of the concrete itself. Therefore, when the volume of concrete is reduced by a given proportion, say x, the total cost of concrete and shuttering is reduced by a smaller proportion. In the first case this is $\frac{3}{4}x$ and in the second it is only $\frac{1}{2}x$.

By working out a few examples on this basis of split costs one finds that the saving in cost of the concrete is not nearly as much as that indicated in the article and is usually less than the increased cost of the steel.

Yours faithfully,

EDWARD P. THORNTON.

18 Walnut-lane, Hartford.
December 12, 1957.

SIR,—I would like to comment on the letters that you have published in your columns relating to my article on the above subject.

The letters of Mr. Geoffrey Brock[1] and Dr. H. Tottenham[2] make substantially the same point, and I will deal with that first. I could not agree more that the ultimate load theory is a superior basis for design compared with the elastic theory. It is none the less true, unfortunately, that the elastic theory is still used and taught very widely in this country; if the elastic theory is being used and an economy can be made without contravening either the theory or the maximum permissible stresses, then it is perfectly correct to make that economy. If the form taken by the economy is startling, or it is suspected that it is made at the cost of a reduction in the safety factor, then it is the theory that should be examined. As Dr. Tottenham says, the elastic theory has been discarded in many countries (as has the use of uneconomical steel-framed buildings, to which I referred) and if the only effect of my startling conclusions based on the elastic theory were to accelerate the dropping of that theory in this country I would be the last to complain.

The stated purpose of my calculations was to test the validity of the assumption that we should automatically use the maximum permitted stresses as the maximum design stresses. Since for one design theory (which, even if not a very accurate one for reinforced concrete, could conceivably be exactly valid for some hypothetical materials) it proved not to be a valid assumption, it follows that for every other design theory the assumption should be tested. The assumption should then only be made if the optimum stresses (for the range up to the maximum permitted) coincide with the maximum permitted stresses, which may often be the case. I chose the elastic theory for this first exercise because it is very widely used—I suspect that considerably more than 50 per cent. of reinforced-concrete beam designs are still based on it—and because the new Code of Practice was not then available, with the standardised form for the ultimate load theory.

I have found Dr. Tottenham's calculations using the ultimate load theory rather difficult to follow. For his first few equations he has used the symbol L, which I use to denote total cost per foot (as he does later), where he should have used b and, furthermore, in reaching his equation (*c*) from his previous line he has lost a $\frac{1}{2}$ sign. I should like to deal with the case of the ultimate load theory more fully, but can hardly do so within the scope of this letter. I hope that I may be allowed to do so in a future issue of ENGINEERING.

With regard to the case of a slab, using the elastic theory, Dr. Tottenham's comments are only partially true. If both b and d are fixed by other considerations, the maximum concrete and steel stresses are indeed not independent of one another, and as he says, it can be shown that the cheapest sections are produced by using the maximum permissible stress of whichever is the limiting material. This position still does not tell the designer which is the most economical quality of each material to use.

In the case of a slab, or where b is fixed by some other consideration, the maximum stresses can again be treated as independent and variable, provided that d is not fixed. The solution for this problem would again best be dealt with separately.

Referring now to Dr. K. Hajnal-Kónyi's letter,[3] many of the above comments again apply. However, I should like to make some specific comments on his letter. Dr. Hajnal-Kónyi remarks that my statement that expensive high-tensile steels give no advantage in cost over mild steel is contradicted by my curves. Where the optimum steel stress approaches 25,500 lb. per sq. in. the minima of the curves are very flat, and it can be seen that the cost equivalent is lower for a cheaper steel, albeit at a lower stress. Perhaps this does surprise the practising engineers whom he mentions, but as he goes on to talk of "wrong education," obsolete text-books, and "mental inertia of engineers," he seems to condemn his own argument. Of course there are cases, as Dr. Hajnal-Kónyi cites, where other considerations, such as difficulty in the accommodation of the steel, restrict the designer, whatever the stresses he uses. These considerations do not alter the fact that, until such restrictions are encountered, the designer should aim at the most economical structure.

With regard to his comments on the unsuitability of the elastic theory for reinforced concrete design I support Dr. Hajnal-Kónyi emphatically; unfortunately, with the publication of the 1957 Code of Practice the elastic theory did not disappear overnight. Perhaps we may be more enlightened some years hence, if and when the latest theories become discredited.

I am grateful to Mr. D. N. Mitchell and Mr. C. W. A. Reay[4] for their useful discussion on the value of the steel/concrete cost ratio r. Clearly, if their prices and mixes are accepted, their result is valid. However, I think that they have arrived at an extreme value. Using their prices for cement and aggregate, and the mix specified by the 1948 Code for 1,500 lb. per sq. in. concrete, I have arrived at a cost of 3*s*. per cub. ft. The British Iron and Steel Federation quote a current price of just over £40 per ton for fairly large quantities of mild steel reinforcement, which is higher than the older price that I used. These values give a cost ratio *for materials alone* of between 50 and 60. As I stressed in my article, it is necessary to add on to this cost all the indirect charges that are incurred by the use of each material. I was not able to obtain any reliable figures for those indirect charges and, in this respect, I thank Mr. E. P. Thornton for the details he gives in the above letter. Nevertheless, I still suggest that these charges are very much greater for concrete than for steel. To obtain their final prices, Messrs. Mitchell and Reay add on approximately the same percentage to the materials costs and omit the cost of shuttering. I suggest that they have underestimated the true indirect costs for concrete, and that the value of r is unlikely, in fact, to be greater than about 30. This value corresponds very closely to a cost ratio by weight that was quoted by Professor A. L. L. Baker in the article to which I referred. However, if any readers are satisfied that in their case a value of r higher than 30 should be used, they have only to do the calculations to extrapolate my curves, and adjust my conclusions accordingly.

Finally, I should like to thank your correspondents for the care and interest that they have shown over my article, even if some of them, in taking the opportunity to cast justifiable brickbats at the elastic theory, have mistakenly aimed in my direction.

Yours faithfully,

J. R. LAWRENCE.

Appletreewick,
Roke-road,
Kenley, Surrey.
December 16, 1957.

[1] November 22, page 644.
[2] November 29, page 677.
[3] December 6, page 708.
[4] November 22, page 645.

WITH the first issue of ENGINEERING for 1958, several improvements in design will be introduced.

The overall page size will be reduced from 14¼ in. by 10¼ in. to 13¾ in. by 10⅛ in., to make the journal easier to handle. The area and amount of editorial matter will not be diminished. A livelier design of cover will conform with recommendations of the British Standards Institution, Aslib and other organisations whose members represent the users of technical journals.

Full details of the changes were given on page 709 of our issue of December 6.

TELEVISION EXTENSIONS

The B.B.C.'s permanent television transmitting station at Douglas, Isle of Man, was opened during December. It replaced the temporary lower power station on the same site, which was brought into operation in 1953. The new station operates on the same frequencies as that of the temporary station (channel 5, vision 66·75 Mc/s., sound 63·25 Mc/s.) with vertical polarisation. The maximum effective radiated power will be 2·8 kW—more than 10 times that of the existing station.

In conjunction with the B.B.C.'s television station at Davis, Northern Ireland, and the new station at Sandale, Cumberland, the Douglas station will bring well over 90 per cent. of the population of the Isle of Man within the range of a strong television signal.

Early next year an improved vision link giving better quality pictures will be provided for the new station. At present the vision signals for the Douglas transmitter are obtained by direct reception, at a nearby receiving point, of the Holme Moss transmissions. Because of the distance involved, picture quality has been adversely affected during periods of poor reception conditions. With the new link under construction, the vision signals will be picked up at a receiving station on Snaefell where a strong signal is obtained from Holme Moss, and then fed to the Douglas transmitter by way of a u.h.f. radio link.

The B.B.C.'s permanent medium-powered television transmitting station at Sandale, Cumberland, was also opened during December. It replaces the temporary low-power station, on the same site, which was brought into operation in November 1956. The new station operates on the same frequency as the temporary one (channel 4, vision 61·75 Mc/s., sound 58·5 Mc/s.) with horizontal polarisation. It has an effective radiated power of 16 kW, some 32 times more than that of the existing station, and will bring the B.B.C.'s service to the greater part of Cumberland and Westmorland, as well as the coastal areas of south-west Scotland and the north-eastern part of the Isle of Man.

Sandale is also to be a v.h.f. sound broadcasting station, starting in the spring of 1958.

Companies in the News

Prosperity in Sheet Steel

Both the Steel Company of Wales Limited and John Summers and Sons, Limited, have recently announced very good trading results for their latest complete financial year. They also share the experience of having done even better than fairly optimistic forecasts on their part suggested earlier in the year. In the financial year 1956/57 The Steel Company of Wales increased its trading profit by 18½ per cent. This represented an advance from £14·2 million to almost £19 million. John Summers have announced an expansion in group profits to £11·2 million for the financial year ended September, 1957, from £9·4 million—an advance of 18 per cent.

Both companies continue to benefit from the steel development programme and their results have been particularly favourably affected of late by the continuing good market for sheet steel. The boom in the motor-vehicle industry has been the main cause for this. The Steel Company of Wales has been probably slightly adversely affected since the end of its last financial year by easier conditions in the tinplate market and John Summers' prospects would not be improved if there was a substantial decline in the building industry, a development which cannot be entirely ruled out in view of the falling off in building plans approved over the last few months.

Steel production as a whole for the 11 months ended November, 1957, was still running at over 5 per cent. above the same period of 1956 but the weakness in tinplate had begun to affect other parts of the steel industry especially light sections. There has been no sign yet however of a recession in the demand for sheet steel and both these large steel companies turn the calendar year with good prospects.

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Nickel's Hopes

Nickel producers have been most careful not to damage their long-term prospects by allowing prices to rise too high. They consider, rightly enough, that they must thrive in rising consumption, provided they can benefit from the immense rise in the demand for special high temperature alloys.

Output of stainless steel, which accounts for about one-quarter of present consumption, has grown four times as fast as all other steels since 1939. There are numerous possibilities for further rapid increases, including the development of guided weapons, the trend towards higher temperatures in the operation of power generating equipment and the possibility of the gas turbine being adopted for new large-scale applications.

The present situation is far different to that even six months ago. Producers may now have difficulty in selling all their output, which has been greatly expanded in the past few years. Yet there is an underlying current of optimism in the industry, based on the growing availability of the metal. International Nickel recently commented that the new situation was "the most encouraging set of conditions which have faced the nickel industry for a long time." It will no longer be necessary, said their market development manager, "to hesitate in the development of new products in which nickel will play a vital role."

Prices have tended to fall, though International Nickel report in their interim statement that "higher prices for nickel" partially offset reduced copper prices, strikes, and increased operating costs. They are proceeding with their expansion programme involving the expenditure of 175 million dols. to raise output from 185 million lb. in 1956 to 385 million lb. in 1961, mainly from the Moat Lake project in Manitoba. There is every hope therefore that users will get all the nickel they want during the coming year and that nickel producers will find many more users.

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Synthetic Phenol at Grangemouth

The announcement that British Hydrocarbon Chemicals are to build a large new synthetic phenol plant at Grangemouth, represents a further important expansion of the British petroleum chemical industry. The new plant, together with the polythene plant already under construction will cost over £8 million and both will be completed in 1959.

The expansion of the petroleum chemical industry is by no means confined to this country and according to a working party of the Chemical Products Committee of the O.E.E.C. (European Organisation for Economic Co-operation) the total carbon content of petroleum chemicals (including synthetic rubbers) produced in member countries, rose from about 200,000 metric tons in 1953 to 400,000 metric tons in 1955 and 470,000 metric tons in 1956. In 1957, the figure was expected to be nearly 580,000 tons and in 1960 over 1·2 million tons.

Expansion of the United Kingdom industry took place relatively early and in 1955 the United Kingdom accounted for 50 per cent. of the output of all O.E.E.C. countries. In 1956, owing to more rapid expansion on the Continent, the United Kingdom share fell to 44 per cent. but with a total annual investment in this country of some £45 million in petroleum chemical plants, the United Kingdom is likely to continue to occupy a dominant position in the industry. The new plant to be erected by British Hydrocarbon Chemicals will produce phenol by the conversion of cumene, a process developed by the Distillers Company which owns British Hydrocarbon Chemicals jointly with British Petroleum. This process produces substantial quantities of acetone as a by-product, of which there may well be a temporary over supply. In addition to its use as a solvent and in the production of cellulose acetate, however, acetone is itself becoming an increasingly important raw material for chemical synthesis, including the production of methacrylic acid. With continued expansion in the plastics industries, any over production of acetone will probably prove to be of temporary duration.

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English Electric Supply Indian Railways

On December 14, Mr. Nehru, Prime Minister of India, will inaugurate the first electrification scheme on the Eastern Railway of the Indian Railway Board, between Calcutta and Burdwan, 59 miles to the north. The English Electric Company has supplied twelve 3,120 h.p. electric locomotives which are the first to be commissioned in India using 3,000 volt direct-current. They can haul anything from a 630 ton passenger train (about 14 coaches) at 70 m.p.h. to a 2,300 ton freight train at nearly 45 m.p.h. The locomotives weigh 112 tons. Built by the Vulcan Foundry, now part of The English Electric Group, these locomotives demonstrate the long association which the company has enjoyed with the Indian railways. In all, Vulcan has supplied 2,750 steam locomotives since the inauguration of the first railway in India, in 1853—with a Vulcan-built locomotive.

In 1925 English Electric supplied the electric rolling stock for India's first electrification scheme between Bombay and Tharna, and since then has trans-shipped 23 locomotives, and electrical equipment for 371 coaches. The new electrification in Calcutta has been provided to cater for the greatly increased traffic in the new industrial belt around Bihar and West Bengal, and will later be extended to Moghalsarai.

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Drilling for Success

The progress of the Cementation Company since the war has been considerable and shows no sign of slowing down, although there has been an increase in competition in most markets. Their chairman, Mr. A. R. Neelands, told his shareholders that the year ended at March 31 had been one during which "all our departments have been working to capacity both at home and abroad." Although he could not guess at the effect of the higher Bank Rate, Mr. Neelands indicated that there was every prospect of a further improvement during the current year. The main obstacle in the way of a further considerable increase in activities is the policy of credit restriction followed by most of the Governments of the Western Hemisphere. Despite this he found the trend of business "encouraging" and reported a level of orders higher than ever before.

Mr. Neelands had interesting developments to report in the techniques used for shaft sinking and in the development of new methods of construction. Competition, he said, had been "successfully countered" by improving the efficiency of operation and by extending activities (mainly in the constructional engineering field). There have been a number of developments. For example, new methods of consolidating old mine workings at shallow depth by working from the surface, in anchoring heavy-duty cables for pre-stressing and faster stressing various structures both in rock and relatively soft strata, and in specialist applications of both light-weight and extra heavy-weight joints for various constructional requirements.

The volume of cementation work carried out in the United Kingdom was substantially higher than in the previous year and several important schemes are proceeding overseas. Among these are the Doman Dam cementation contract in Iraq, progressing ahead of schedule, which is a joint venture under the company's supervision. Constructional activities in India, in association with the Patel Engineering Company of Bombay, include the preparation of the site for the £100 million steelworks at Durgapur. At home the recent award of the Ffestiniog pumped storage hydro-electric scheme is the first of its kind in the British Isles. There are many other developments, such as the trial plant at Battersea power station for the manufacture of "Terlite," which may solve the fly-ash problem. The prospects of the company appear very good indeed.

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Forming Metals

The world's output of metals is about 350 million tons a year and almost all of this goes through a forming operation, involving pressing, rolling or extruding from ingots or billets.

A Shell Film Unit cinema film in colour and with a sound commentary, entitled "Forming of Metals," was shown in London recently. It deals with all the main forming processes, comprising hot rolling, cold rolling, annealing (including bright annealing), forging (including drop forging, the forging of wagon wheels and the production of thick-walled tube by billet piercing), tube and wire-drawing, extrusion, pressing, and drop stamping. Micro-photographs and models are employed to describe some of the processes and to demonstrate how the metal is given particular physical properties. Attention is also drawn to the importance of lubricants in various forming processes.

The film runs for 28 minutes and was directed by Mr. Peter de Normanville. Locations were chosen in the factories of some eight metal companies. Inquiries regarding the showing of the film should be addressed to Shell-Mex and B.P. Limited, Shell-Mex House, London, W.C.2.

Plant and Equipment

ELECTRICAL CONTACTS

Modern Acoustics Limited, Boreham Wood, Hertfordshire, are now making available a new and comprehensive range of plugs and sockets. The range will be manufactured in the United Kingdom under licence from Tuchel Kontakt, Germany. The patent contact principle used is based on the theory that it is more important to keep surfaces free of oxide film and dirt than to increase contact pressure.

Basically, the contact consists of a series of tubes of decreasing diameters, opened longitudinally with two or more transverse slits, assembled one within the other. Fig. 2 shows the form of construction. In operation, the bevelled contact blade is inserted into the first split cylindrical spring bank A and, as the blade is thicker than the gap, the spring assembly is forced apart and each of the three springs grips the blade pincer fashion. As the blade is introduced, the front edges of the spring assembly rub against it, cutting through existing dirt or oxide film. The process is repeated through banks B and C.

A feature of the construction is that the spring banks are not rigidly secured. They float in the connector assembly. The floating action ensures that the pressure exerted by the individual springs upon each side of the contact blade is always balanced. The manufacturers claim, as a result of the construction adopted, the following advantages for the new range: low contact resistance with large contact area, insensitivity to vibration or temperature changes, and simple engagement or disengagement.

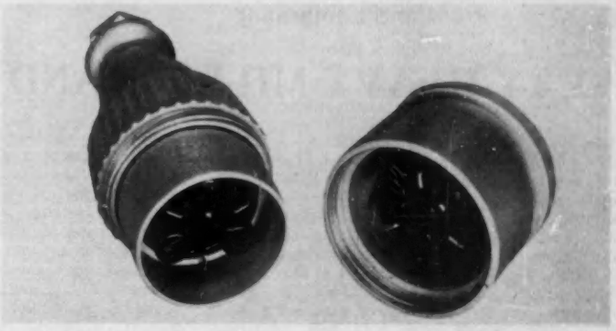


Fig. 1 Illustrated here is a typical heavy duty connector using the patent contacts. Economy is achieved by using identical mouldings for the mating halves.

Initially, production of the connectors will be limited. However, deliveries can be made immediately, either from production at Boreham Wood or from imported German components. The plugs and sockets available range from small ¾ in. diameter six-pole units, or less—each pole carrying 5 amp. at 125 volts—to larger 5 in. diameter 36-pole units in which each pole carries 60 amp. at 500 volts. Fig. 1 shows a six-pole 20 amp. 1,000 volt connector.

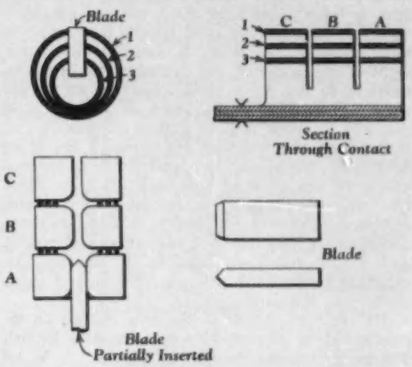
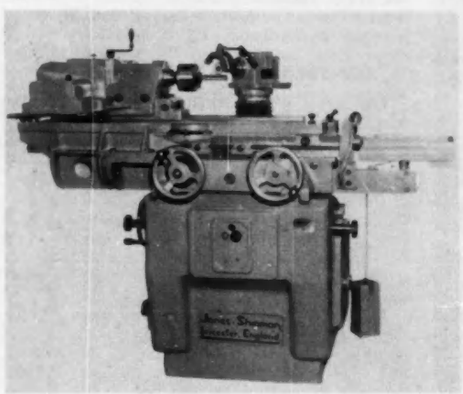


Fig. 2 (right) The patent Tuchel contact.



HELIX GRINDING

Machine for Cutting up to 35 Flutes

A modified version of one of their tool and cutter grinders, specially arranged for helix grinding, is announced by A. A. Jones and Shipman, Limited, Narborough-road South, Leicester.

Helical motion is imparted to the work by means of a steel tape encircling a drum, and a tape carrier which is given a rectilinear motion by a roller in contact with a sine bar. The main spindle and tape drum are mounted in ball bearings in a standard base, which bolts to the work-table of the machine. On the underside of the tape-carrying cross-slide is a roller, which contacts a sine bar secured to the main cross saddle of the machine. This sine bar is used for low-angle leads over 9½ in. For high-angle leads under 9½ in. the roller contacts a sine bar carried on longitudinal extensions of the main machine cross saddle. When grinding high-angle leads the machine head is operated by means of a handle, for low angles it is controlled through the normal machine table traverse handwheel. Fine screw adjustment is provided, and it is possible to grind a range of flutes, the numbers being 2, 3, 4, 5, 6, 7, 8, 12, 24 and 35. The work can be turned through up to two revolutions by the drum and tape gear.

USING TROUGHED BELT CONVEYORS SAFELY

TROUGHED belt conveyors are familiar for handling granular materials, and their use is increasing. A user of such conveyors has certain statutory obligations under the Factories Acts, intended to ensure that they shall be used safely, and that potentially dangerous parts shall be guarded by adequate fencing. At the same time, the user is obviously concerned with seeing that conveyors continue to operate and do the work for which they were intended. These two requirements are not—they must not be—incompatible. In fact it is suggested by a recent survey of the subject* that the reverse is the case, and that proper accident-prevention measures aid rather than interfere with conveyor operation. Some operations, such as lubrication, and the clearance of spillage and of build-up on pulleys, are particularly fruitful sources of accident. The author of the paper shows how these necessary operations can be carried out safely without stopping the conveyor.

The history of belt conveyor accidents shows that the majority of accidents are to people trapped in the nips where belts and pulleys meet. Causes of the accidents vary, but many of them are the result of hand tools being trapped in the nip while clearing spillage or build-up; the operators try to free them, and get trapped themselves. Injuries resulting from accidents of this type are usually severe, and are sometimes fatal. Another fruitful source of accident originates in operational difficulties. To clear the trouble the operator has removed a guard or fence and, because the need for attention has recurred, has failed eventually to put the fence back in position. A potential hazard is thus created, and sooner or later an accident is likely to occur. Faulty or inadequate fences, or even lack of fences altogether, are obvious sources of hazard.

As a first step towards the prevention of accidents the author has drawn up a list of principles to be applied. He defines these as: safe and sound plant design; fencing of dangerous parts; safe starting and emergency stopping; proper rules for operation; planned inspection and maintenance; and training of operators. The detailed recommendations are too lengthy to be included here in full, but they can be summarised.

Design and layout cannot fail to benefit from consultation at drawing board stage between mechanical designer and safety officer, who will also be able to point out the fencing requirements. It is not sufficient to fence simply to prevent a person coming into accidental contact with the conveyor. Such fencing is, of course, necessary, especially where persons have to walk by, over or under a conveyor in the normal course of their duties. Fencing must also be detachable, substantial, and as close as possible to the parts to be protected. Obviously, it must not be provided with gaps or doors for access to the machinery.

Starting arrangements should be, if possible, at some central point from which the whole length of the belt can be seen. If this cannot be arranged, there should be a warning device, audible throughout the length of the belt, interlocked with the starter to operate for a period before the belt begins to move. Stopping must be made as easy as possible, and the belt must be capable of being brought rapidly to rest in an emergency. The simplest and most effective device for stopping the belt is a trip wire extending along its entire length. Emergency stops must be tested regularly, at least once a week.

Safe operation can best be achieved if a precise code of instructions is issued, and this involves training the operators, who must be instructed, at least by the foreman, in their duties, and not left to find out as best they can what they have to do. Planned operation will include maintenance, and either manual clearance of spillage and pulley build-up, for which purpose the conveyor is stopped, or alternatively, mechanical clearance, which is continuous, behind the fences, and controlled from outside.

* "Accident Prevention in the use of Troughed Belt Conveyors," by A. A. Beckingsale, M.I.E.E. Given as a paper at the National Industrial Safety Conference of the Royal Society for the Prevention of Accidents, 1957, and now reprinted as a booklet by the Central Electricity Authority, Winsley-street, London, W.1.

Continuing **Plant and Equipment**

VERY HEAVY MILLING AND BORING

The latest addition to the range of machines made by William Asquith, Limited, Halifax, and marketed by Drummond-Asquith (Sales), Limited, King Edward House, New-street, Birmingham, 2, is described as a horizontal milling and boring machine. In the placing of the word boring second in that simple description, there is greater significance than might at first appear. The advantages of horizontal-spindle boring machines for certain types of machining other than plain boring have long been apparent, and a boring machine used for milling is a common sight in machine shops, especially on large components, where it may be more convenient to traverse the machining head in relation to the work, rather than to move the work itself. In recent years it has become possible to work milling cutters at speeds and feeds which are too high for some of the older boring machines, and the need for new, heavier machines has become apparent. It is to meet this need that the new Asquith machine has been designed primarily for heavy milling on large components, but also as a fully-equipped boring and facing machine, capable of all that an ordinary borer would do. A full range of extra equipment is available.

The first machine of the new design to be completed is one of two for the new British Thomson-Houston works at Larne. It is of 10 in. spindle nominal capacity, the largest size in the range, which extends down to 5 in. spindle. Dimensional details, speeds, feeds and power are summarised in the appended table. On the first two machines the main driving motor, which, like all the other electrical equipment, is of B.T.H. manufacture, is of 50 h.p. This is adequate for the particular purpose, but the design of the machine allows for the fitting of a motor of 100 h.p.; this size is, in fact, listed as standard equipment. In all there are 14 motors with a total horse-power of over 300.

Spindle diameter	10 in.	253 mm.
Driving flange of milling sleeve, diameter	23 in.	584 mm.
Travel of ram	5 ft. 0 in.	1,514 mm.
Travel of spindle in ram	6 ft. 6 in.	1,981 mm.
Vertical travel of slide on column	15 ft. 0 in.	4,572 mm.
Horizontal travel of column on bed	33 ft. 0 in.	10,058 mm.
Width of bed over slideways	11 ft. 0 in.	3,352 mm.
Range of speeds, infinitely variable with use of mechanical changes and variable speed motor	1 to 300 r.p.m.	
Dimensions of ram	28 in. × 36 in.	711 × 914 mm.
Approximate net weight, not including electrical equipment	233 tons	

RAM AND SPINDLE

To achieve the great rigidity required for heavy milling, the machine is fitted with a large-section rectangular ram, mounted in the slide, which can be extended to a maximum distance of 5 ft. The ram, which carries a milling sleeve, has feed and quick power-traverse motions and micro-setting, and is locked by power. Thrust loads are taken on precision ball and roller bearings, which are mounted as near to the cutter as possible; linear expansion caused by a rise in temperature during a prolonged milling operation will not affect the depth of cut. Milling cutters are mounted on a flange at the front of the sleeve, and there is also provision for fitting a surfacing slide attachment.

The boring spindle slides in the milling sleeve, and can be extended to a maximum of 6 ft. 6 in. from the ram, when the latter is at any position. Spindle rotation is from the milling sleeve, and the same gearing provides the feeds for both the spindle and the ram; either can be used with power feed, but it is not possible to use both simultaneously. There is no separate motor for the spindle and ram feeds and traverses. Instead, power is taken from the spindle rotation motor, through electro magnetic clutches, which enable either direction of feed to be obtained, irrespective of the direction of spindle rotation. There is also a hand operated motion. When the ram and spindle are traversed for screw-cutting, the electro magnetic clutches are by-passed by a separate train of gears.

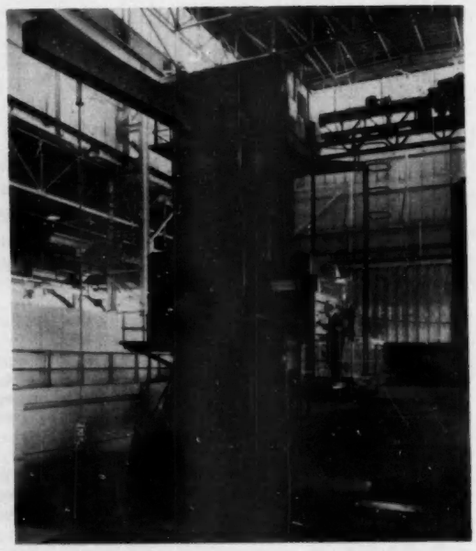
Both the column and the slide are equipped with rapid power traverse by means of 30 h.p. motors, the traverse speed being 8 ft. per minute in both cases. Direct-current injection braking reduces the over-run on stopping to $\frac{1}{16}$ in. Micro-inch motors, rated at 5 h.p., are also provided on both column and slide motions, and these produce a speed of 0·1 in. per minute. The over-run, with direct-current injection braking, is about 0·0005 in.

For ram and spindle quick power-traverses there is a common motor, rated at 7·5 h.p., and for micro-inch traverse a second common motor, of 1 h.p. Motion-selecting levers on the spindle gearbox enable either motion to be applied to ram or spindle.

Locking of all motions is electro-hydraulic, four locks being used on the column, slide and ram traverses, and one on the spindle. The locks consist of a pad which is forced home by a screw turned by a vane piston in a hydraulic cylinder. Oil at 1,000 lb. per sq. in., applied to one side of the piston or the other, gives positive locking and unlocking. Pressure build-up on a pressure switch is used to terminate the locking action, and the system is thus self-compensating for wear. Electrically, all that is necessary to operate the locking gear is to energise the 3 h.p. pump motor and one of two solenoid valves which control the oil flow directionally to the cylinder. After the system has locked or unlocked, as the case may be, pressure build-up causes the pump motor and solenoids to be de-energised. Once the movement has taken place, therefore, removal of power from the machine has no effect.

The drives and controls of the machine incorporate some unusual features. By the use of direct-current motors, infinitely-variable in speed, and a patented system of gearing, mechanical gear changes have been eliminated altogether in the horizontal and vertical feed movements, and in the spindle drive the number of gear changes has been reduced to four. Constant horse-power is available at the spindle for each speed, together with the additional advantage of full power at any speed of the spindle between 10 and 276 r.p.m.

The feed motors for horizontal movement of the column and vertical movement of the slide are both rated at 20 h.p. between 1,500 and 500 r.p.m., and have a bottom speed of 37·5 r.p.m. Feed is variable in both cases from 20 in. to ½ in. per minute.



Shown under erection in the maker's works, this Asquith 10 in. milling and boring machine is the first of a new range designed for heavy feeds and high speeds.

Among the available extra fittings is a universal milling head, which bolts to the face of the ram.

CONTROL SYSTEM ADVANTAGES

The use of Ward-Leonard controls makes it a simple matter to group the speed and feed setting controls together on a main control panel built into the spindle gearbox. It also gives very rapid acceleration and deceleration of the spindle which can, in fact, be accelerated to, or stopped from, full speed in about 3 to 4 sec. Likewise, the speed of the spindle may be pre-set, and the motor accelerated up to it. Any adjustment of the controls while the motor is running effects a rapid change.

A further feature of the electronic Ward-Leonard feed drives is a steering control, which permits simultaneous operation of the column and slide feed motors, so that the spindle may be made to feed in any direction in the vertical plane. Steering is under the control of a selector switch, a feed-rate setting control and a direction-setting dial, all located on the main control panel. The feed can be from 2 in. to 20 in. per minute, and once set remains the same, whatever the direction may be.

The main control panel is mounted on the slide, and carries push-buttons and dials for all the motions. Change speed and feed gear levers and hand motion wheels for ram and spindle movement are adjacent to the control panel. All traverses are equipped with graduated scales and verniers, and telescopes, prisms and mirrors are fitted where necessary, so that readings can be made at the central control point, where a platform and handrail are provided for the operator. For convenience in setting, or in operating the machine from the work instead of from the platform, a power-operated pendant box is slung from a jib on the column, with duplicate push-buttons.

A range of extra equipment is available, including 2 ft. and 4 ft. diameter surfacing slides, which are bolted to the face of the milling sleeve, and take their hand and feed adjustments from the machine slide. For increasing the milling range there are available a universal milling head and a right-angle attachment. Both bolt to the face of the ram. A two-ton electric hoist, carried on a jib from the top of the machine column, facilitates changing of attachments without the necessity for using the shop crane.

Management

Weekly Survey

Earnings of Australian Engineers

The employment of graduates in British industry has been written and talked about at great length in the past year. A pamphlet published by the University of Melbourne Appointments Board carries the discussion to Australia. The pamphlet is based on a survey of professional incomes in Victoria. The engineers included were either associate or full members of the Institution of Engineers, a qualification requiring three years post-graduate experience in industry. The median age for the engineers considered was 43 years. Three-quarters of the sample were in the service of the Commonwealth or State governments or municipalities. About a fifth were in private firms.

On average salaries, the engineers came out fourth, following doctors, lawyers and dentists. They were ahead of architects, chemists and accountants. The breakdown of income shows a rather different picture. Only 10 per cent. of engineers get over £3,000 a year compared with doctors 46 per cent., lawyers 31 per cent., dentists 28 per cent., architects 14 per cent. and chemists 12 per cent. On the other hand, 38 per cent. of engineers earn from £1,500 to £2,000 and another 38 per cent. from £2,000 to £3,000. Fewer engineers are in the under £1,500 class than in any of the other professions considered. So far as age is concerned, Australian engineers reach a figure near their maximum salary between 40 and 44 and maintain this right up to retirement. The earnings of doctors, dentists and lawyers, on the other hand, begin to fall after 55. Size of salary and type of employer are closely correlated. The engineers in the top bracket are all " sole practitioners or partners." They are well ahead of those in Commonwealth, State and Municipal service. At the upper end of the scales the sole practitioners are getting £3,500 compared with £2,300 in public service. Engineers in private firms start below those in public service but can work up to salaries two or three hundred pounds higher on maximum.

The survey ends by showing that engineers have not succeeded in maintaining their real incomes quite so well as agricultural scientists, lawyers, architects or accountants. Nevertheless, from the outline given in the survey it is clear that qualified engineers are at least as well rewarded in Australia as here.

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Friday Isn't Pay Day Any More

The difference between wages and salaries is a fundamental one in any society. White collars and a monthly pay cheque go together. Social class, prestige, and make-up of the family budget are all involved. In Germany there has been a move by industrial firms to get their workers to give up the weekly pay packet for a monthly or fortnightly payment. A wide variety of different schemes are coming into use. Some firms pay their workers three times a month. The first two payments are in the nature of advances, the third settles up the account. Almost all payments, however, are still made in cash. The German worker puts up the same sort of arguments against being paid by cheque as were heard here when the matter was raised in Parliament a few months ago. The best that any company has achieved in this direction is to give employees the choice of cash or cheque.

The new systems have several advantages. Firms need have less ready cash in hand each week-end, and they can have the same pay day for manual and clerical workers. The number of pay days is cut down from 52 to 26 or even 12, with great saving of office time. The critics of the new schemes put forward all the old familiar arguments. The working of " calendar arithmetic " means bringing their pay day forward in some months because of Sundays or holidays. Pay days would have to be anticipated by the workers, especially in periods containing two or three week-ends. Whether or not a particular firm decides to change its pay system is decided by the Works Councils, the *Betriebsräte*. In the bigger firms of the Ruhr the number of workers asking for monthly pay days is going up. One reason for this is that the German manual worker resents being treated differently from the white collar man. Many skilled workers make much more money than the people in the offices, and regard it as a logical step forward that they should have the same treatment. This is a point on which both trade unions and employers agree. It will take some time, however, before traditional usages and attitudes on both sides are broken down.

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Gas Turbines for Ship Propulsion

In a paper entitled " The Trials and Maiden Voyage of the Gas Turbine Ship ' John Sergeant ',' " read before the Institute of Marine Engineers on December 12, Mr. J. J. McMullen, president of the Hudson Engineering Company, and formerly chief of the Office of Ship Construction and Repair in the United States Maritime Administration, predicted a marked expansion in this method of ship propulsion. The John Sergeant is a converted United States Liberty ship which has been operating with a gas turbine propulsion unit for over a year as part of an experiment aimed at developing advanced types of improved propulsion plants for the new ships of the United States Maritime Marine to be built during the next 10 years. As part of the same experiment, a second Liberty ship was fitted with a free-piston gas generator/turbine plant.

The gas-turbine unit in the John Sergeant was designed for a normal power rating of 6,000 s.h.p. and the ship made a speed on trials of 17·31 knots, with a fuel consumption using bunker C fuel of 0·5228 lb. per shaft horse-power hour. Mr. McMullen predicted that about 25 per cent. of the dry cargo ships utilising more than 7,000 s.h.p. ordered in the United States during the next 5 years will be gas-turbine propelled.

The United States was comparatively late in entering the marine gas-turbine field, since in this country experience was gained as early as 1947 in a small naval vessel while on the commercial side a gas turbine has been used to provide part of the power to propel the Shell tanker "Auris" since 1951. If, however, Mr. McMullen's forecast is achieved, the United States will quickly assume a leading position in this field.

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French Aircraft Challenge

It was announced last week that, between the end of the war and October 1, 1957, total export orders received by the French aircraft industry were valued at £105 million at the pre-devaluation exchange rate. This figure is of the same order as the value of only a single year's aircraft exports from the United Kingdom. The big challenge now being made by the French aircraft industry in export markets is, however, shown by the fact that only a little over £9 million worth of orders were won before 1956. Export orders received in 1956 amounted to about £25 million and in 1957 to £70 million.

The Sud Aviation Caravelle jet airliner has received the most publicity and has been ordered by Scandinavian Airlines System and Varig, the Brazilian airline, in addition to Air France. The challenge of the French aircraft industry is, however, broadly based and the principal machines exported include the two jet trainers, the Fouga Magister and the Morane-Saulnier Paris, the Dassault Mystère jet fighter, the Nord 2,500 transport aircraft and two helicopters, the Alouette and Djinn built by Sud Aviation.

The Caravelle is, of course, powered by Rolls-Royce engines and to this extent the total value of export orders received by the French industry is not strictly comparable with the corresponding figure for the British industry, since the former includes the value of a number of British engines. French engine manufacturers are, however, making a place for themselves in export markets and orders have been received for the S.N.E.C.M.A. Atar jet engines and the Turboméca turbine engines.

The French aircraft industry also hopes to sell aircraft in the United States. At the end of October, Morane-Saulnier announced the sale of two Paris aircraft adapted as a twin-jet executive machine to Beech Aircraft, the company's United States sales representative. This was stated to be the first order received by the French aircraft industry from the United States for 20 years. It was also announced earlier this month that the Republic Aircraft Corporation are to manufacture in the United States the Alouette turbine powered helicopter under licence from Sud Aviation. The Alouette is a 5-seater helicopter with a maximum speed of 120 m.p.h. and is powered by an Artouste 2B1 turbine engine manufactured by Turboméca.

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Raw Deal for Private Enterprise

Inconsistency, supposedly an oriental trait and foreign to Western thought, nevertheless lies at the very root of the British Way of Life; and if one half of the nation passionately believes in nationalised industry, and the other half as passionately in free enterprise, what more typically British solution could be found than to set one to compete with the other? In some cases this is probably as sound an answer as any, but in such an exposed industry as air transport, it is doubtful whether real competition on such terms can exist.

The British independent airlines provide services which are by now taken for granted by the travelling public—one need only mention the cross-channel ferry services; but their present situation is not enviable. Passengers carried rose from 552,000 in 1955/56 to 743,000 in 1956/57; the latest figures represent 20 per cent. of the total for all British airlines. In terms of passenger-miles, however, the picture is very different. In the former year, the State corporations accounted for 91 per cent. of all British scheduled air services capacity, a figure which rose to 93·4 per cent. last year. The share of the independents has thus fallen from 9 to 6·6 per cent. though in an expanding market there have been some increases in traffic carried.

In this situation, the British Independent Air Transport Association feel that a new deal for the independents is very necessary. In a foreword to the Association's annual report, the chairman, Mr. G. H. Freeman, states that " the limits of current Government policy have been reached in all but a few cases as far as the independent air lines are concerned. And this . . . during a period when . . . British air transport as a whole is not achieving a satisfactory position in the world." The Association believe that the State corporations cannot by themselves produce the full answer.

The present-day air transport battles must be fought largely by the big battalions. But battles are not won by them alone. The independents have an important part to play, both in complementing the services of the corporations and also perhaps as a thorn in the flesh of the giants—who have their problems too.

Continuing **Management**

THE RISE OF THE BUSINESS ECONOMIST

Commercial Planning on a Systematic Basis

Economic planning may have become a dirty word in political circles, but interest in foreseeing the future and adjusting policy to suit has been growing in the business world during the last few years. A number of firms, mostly of the larger size, now employ economists and statisticians, although these are mainly to be found in the international companies particularly those engaged in commodity production. They are, for instance, well established in the oil industry, in chemicals, in rayon and, to some extent, in papermaking. It is natural that companies whose operations are affected as much by the availability and price of their raw materials as by their markets should be the most interested in this sort of activity.

The engineering industry which, in view of its dependence on investment programmes and exports, might be expected to have a particular interest in this sort of work, has in this country been especially slow to adopt these new techniques. The motor car industry might have avoided its difficulties of the last two years if it had taken the trouble to examine what was happening, not only to our own economy, but to those of many of its main markets. It is perhaps ironical that several of the material and components suppliers of the industry have done more work in this field than the motor car industry itself, a fact which has not always led to comfortable relations between supplier and purchaser. An outstanding example of this is the iron and steel industry, which has always been sceptical of the motor car industry's plans and whose scepticism seems now to have been justified.

An exceptional recent entry by an engineering firm into the field of business forecasting is the General Electric Company whose *Quarterly Export Guide*, which we have already noticed in these columns, is published for the benefit of all who care to ask for it. It is to be expected that large organisations in the basic industries, whose annual capital expenditure runs into many millions, should be the most concerned with foreseeing economic trends. Many of these industries are now the field of the public corporations, all of which have their economic departments and issue regular statements of the forward estimated demand for their products and of their own plans. In the case of the iron and steel industry this function is now performed by the Iron and Steel Board, whose special report on development in the iron and steel industry for the next five years has recently been published. The provision by business of information to Government Departments and the publication of economic and industrial statistics has, at least until recently, been much more highly developed in the United States than in this country and many more American firms employ economists than do those in this country. In Germany, many businessmen and industrial leaders have had an economic training and are capable of making and interpreting economic assessments in a way which British businessmen rarely do.

From the point of view of the individual firm, there are two aspects of business forecasting: one corresponding to a strategical, and the other to a tactical, appreciation. The methods of the tactical study are those of market research; that is to say, a study of the individual markets for particular products. Although this will be based on some background statistical information about the trend of consumer incomes, the nature of consumer preferences, and the shares of particular firms in the market, it also requires field work in the form of reports from local salesman and agents and specially organised consumer surveys. Obviously the techniques for such inquiries must vary greatly as between types of product and, particularly, between consumer and capital goods.

Short-term enquiries are, however, quite inadequate for the guidance of boards of directors in the determination of investment policy. For this purpose, longer-term, strategic economic forecasting is necessary and this can only be done by an adequate economic staff, capable not only of collecting statistics and other economic information but also of assessing both economic and political trends. The raw material for their work will be found in the extensive statistical material now published, not only by the governments of individual countries, but also by such international bodies as the United Nations, O.E.E.C., the World Bank, and so on. Much of this material is collected by our Commercial Officers in foreign countries and Trade Commissioners in Commonwealth countries and can be obtained from the Board of Trade; but it varies a good deal in quality and in comprehensiveness. Contacts with the Commercial Counsellors of embassies and High Commissioners' offices in this country is also useful. In addition to statistics, many countries, especially those undertaking extensive industrial development, now publish national plans, generally covering five-year periods, which contribute to the assessment of world demand for capital goods.

The economic forecaster must make assessments of the trend of growth of national incomes, both at home and abroad, and of its various components as well as any trends in the change of its distribution as between higher and lower income groups. For the home market, it is clearly of the utmost importance to have regard to trends in our balance of payments: for any assessment of the rate of expansion of national income must have regard to the growth of exports, to pay for rising imports, which it implies. If this growth is larger than appears attainable, the rate of expansion, at any rate in the industries most responsible for the adverse trend, must be reduced. It was a failure to take this factor into account that led the motor industry astray in 1955, for the actions taken last year by Australia and New Zealand to reduce imports and by the United Kingdom Government to restrict the sales of durable consumer goods in the home market were not politically arbitrary, but would have been forced on governments of any complexion, faced with the same economic conditions. In fact, they were foreseen by many economists.

Whereas the trend of home market sales, particularly for consumer goods, can be fairly easily assessed, that of exports is obviously much more difficult. Here the forecaster must take account of many political as well as economic factors. These include not only the more obvious things such as war and political disturbances, nationalisation, competitive foreign aid and subsidised trade, but also, and perhaps more important, the economic policies of increasing self-sufficiency pursued by many developing countries. For this reason it is important to learn well in advance of the plans of these countries to develop their own industries, particularly in the field of mass-produced consumer goods where cost is dependent on plant utilisation. For companies manufacturing both capital and consumer goods, the choice must be made as to which field in which to expand and a knowledge of what their customers are doing is obviously a pre-requisite.

A new and important feature in world trade is the establishment of the European Common Market and the British proposals for a Free Trade Area. These themselves will require the most detailed examination, industry by industry and company by company, and they are bound to have profound effects on the investment policies of particular firms. So far the information on which these decisions could be made is largely lacking.

An important step towards remedying our backwardness compared with the United States of America and with Germany in the field of economic forecasting and what the Germans call *Konjunktur Analusis* is the establishment by the National Institute of Economic and Social Research, with the goodwill of the Government and the support of the Ford Foundation and a number of British firms, of a centre for research in economic trends.

Over the past few years a number of Government economists have worked for periods in the Institute and the appointment as director of Mr. Christopher Saunders, until recently deputy director of the Central Statistical Office, is a guarantee that, although the Institute will remain independent, it will receive the full collaboration of Government Departments. It is the intention of the Institute both to cover short-term trends by the regular publication of a series of reports on the current economic situation and to do long-term research concentrated on building up knowledge about the causes of economic change and growth. They intend to give particular attention to the study of the way in which business in the United Kingdom affects and is affected by conditions of overseas trade and so to assist large firms who, in planning their investment and development programmes, have to look five to ten years ahead.

In the growth of economic departments in individual firms there are two possible dangers to be avoided. The first is that the business economist will be treated merely as another gimmick with a certain public relations value; an attitude which would not only entail a waste of money, but would also completely discredit the idea of business forecasting. It is essential that the business economist is treated as part of the top management team and his views, although not taken as gospel, treated with the seriousness they deserve. The other danger is that of the duplication of effort among a number of departments doing the same work in separate firms. The answer to this is surely that the business economists should be encouraged by their firms to co-operate fully with Government Departments and with such bodies as the National Institute so that an appropriate division of labour may take place. It would seem sensible, for instance, that the National Institute should be more concerned with country-wide national and international studies while the individual firm concerns itself more with the prospects for particular industries and products. This is not to say that each may not find out, in the course of its investigations, facts and information of interest to the other. Certainly large companies with international connections and competent overseas staff are bound to be among the most useful of those intelligence agents on which the Institute will have to rely for information which is not strictly quantifiable.

There are here obvious signs at last of really valuable developments in the field of applied economics which may be of great value to British industry and to the British economy in the years ahead; and it is to be hoped that engineering firms, on whom so much of our economic future depends, will be active in taking advantage of them.

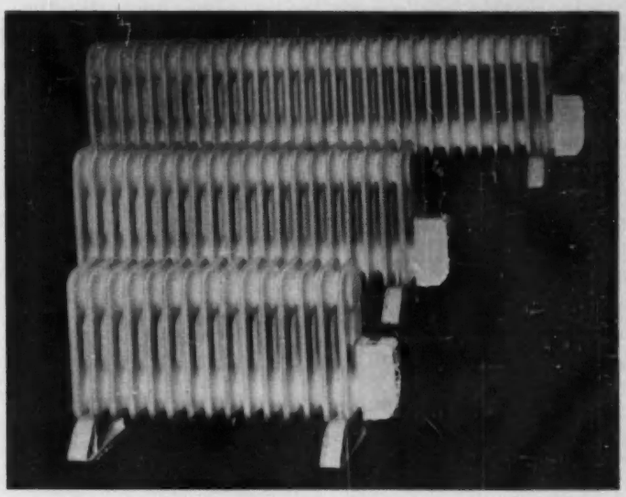
Engineering at Home

LOW HEAT

Beneath unusual windows that reach almost to floor level, under work benches, window seats, and church pews, the "S" series of ultra-low oil-filled electric radiators made by Hurseal Limited, 229 Regent-street, London, W.1, can be fitted.

Three sizes make up the range. The illustration shows the 1·5 kW S15, the 1·0 kW S10, and the 0·75 kW S75. All three are three-column type lightweight pressed steel radiators that stand 10⅞ in. high when wall mounted. Detachable feet increase the height to 13⅜ in.; all may be fitted with castors as an optional extra. Oil-filled electric radiators operate at the same surface temperature as hot water radiators and are in fact their electrical equivalent.

Gulf Radiators Limited, 229 Regent-street, London, W.1, produce a low panel radiator that makes skirting heating installations possible by normal hot-water heating methods. The skirting radiator is 11 in. high. It is light in weight so that wall mounting, giving a clear floor, becomes possible. When requirements demand a considerable heating surface, the narrow width of ¾ in. enables double or triple combinations to be used. The panel radiator can be supplied in any length and in curved or angled forms; thus irregular room shapes present no problems. A valuable feature of the radiator is its smooth surface that harbours little dust.



The S series of oil-filled radiators can fit into a variety of low positions.

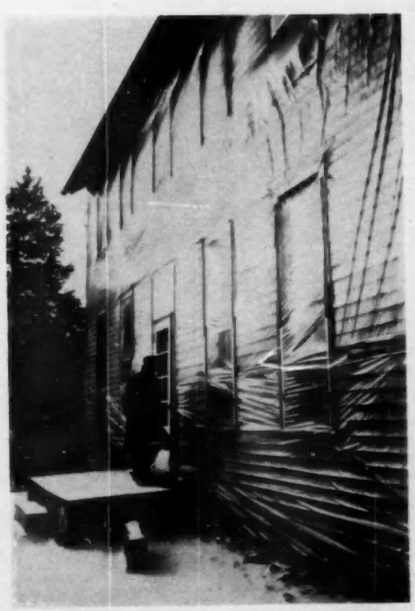
WATERPROOF WALL SURFACES

A hard-wearing decorative wall surface is now being produced and marketed in this country by Springhill Products Limited, Airdrie. It is based on the range of resin paints produced by A/S Linotol of Copenhagen. The new material is known as Linostone and can be produced in any colour and used on any surface, provided normal painting techniques are followed.

The procedure is first to coat the surface by brush, roller or spray with the resin-based paint, and then to impose on this a covering of fine sand or quartz. A clear varnish coating can be applied if required. The final appearance is that of fine stone, and the surface is impervious to water and normal weathering and can therefore be used both internally or externally. Patterns such as imitation brickwork can be obtained by the use of tapes fixed to the surface, over which the paint can be applied. A particularly decorative effect is possible by using different base colours to give a patterned brickwork finish. Being very viscous, it can be built up to form embossing, such as coats of arms and the like.

Other products of the company are Linotol flooring material, which can be used on concrete or wooden surfaces equally well and has been available in Denmark for many years and Linotol resin paints, which give washable surfaces, drying in a few hours. Linotex is a plaster-like resin paint which can be applied to external surfaces such as brick, cement, wood, asbestos or fibre-board, and will give a texture finish that can be patterned to choice.

LIVING UNDER POLYETHYLENE



In an attempt to make a poorly insulated farmhouse more habitable, polyethylene film was wrapped around it from the ground to the eaves.

One winter night, when temperatures in the Northern United States fell to −10 deg. F., the goldfish bowl froze over in the living room of an old farmhouse while the oil burner was running.

Someone who had used polyethylene film—made by Union Carbide International Company, New York—for glazing on greenhouses suggested that the poorly insulated building might be made more habitable by wrapping it entirely in such a film. The film is highly resistant to moisture penetration and retains its durability and flexibility at temperatures well below 0 deg. F. It is also light in weight and easy to install.

The suggestion was adopted. A 16 ft. wide, 100 ft. long strip of polyethylene film (0·002 in. thick) was first wrapped round the house just below the eaves. An 8 ft. strip was then wrapped round the bottom. The top strip was made to overlap the bottom one by several inches. Lath battens nailed around the building at regular intervals held the film in place. As will be seen from the illustration alongside, openings were cut around the doors and several windows where ventilation was essential.

The rehabilitation job has now become a research project, and thermographic records of temperature inside and outside the building are being kept. While it will require several seasons of testing, with new films each year, to produce a reasonable evaluation, it is reported that the family that lives in the farmhouse were able to turn down the oil burner at night last winter, even in the coldest weather.

BUILDING ELECTRICITY

With the increasing use of electricity in the home the need has arisen for all members of the building team to have some knowledge of the capabilities of electricity and of the best way it may be employed. A recently published book, *Electricity in Building*, by Mr. A. L. Osborne, sets out to give an account of the use of electricity in a variety of types of buildings. The book contains the minimum of technicalities. B. T. Batsford Limited, Portman-square, London, W.1, publish it.

An introductory chapter contains basic theory and definitions of units. Later chapters consider principles of installation, wiring systems, control gear, electrical accessories, lighting, space heating, and water heating.

OPEN FIRE

The Airdale fire is recommended by its makers—Richard Baxendale and Sons Limited, Chorley, Lancashire—for people who have a rented house and who may prefer to install an easily portable fire that may be taken with them when they move. It is an open fire that burns coal, anthracite, coke, Coalite, Phurnacite, and Rexco. The makers claim that it will keep a large-sized post-war room warm night and day for a week, using about 1 cwt. of fuel. A feature in the design of the fire is the use of a plate, called the restrictor-reflector, that reduces the chimney draught and also reflects heat into the room. Also air is sucked into a convector chamber at the back of the fire, heated and sent back into the room by way of a gap that exists between the Airdale fire and the brick structure which forms the fireplace of the room. It is suitable for 16 in. and 18 in. wide fire openings, from 20 in. high.

LAGGING DOUGH

A new lagging material for water pipes is being produced by the Dohm Group, Victoria-street, London, S.W.1. It is a plastic dough that is supplied in powder form. It is called Warmlag. Now available in 5 lb. packs, it can be used to protect pipes against frost or to prevent heat losses. One pack will cover 60 in. of ½ in. pipe, 48 in. of ¾ in. pipe, or 2 sq. ft. of a tank.

The powder is mixed with water and a thin undercoat dabbed on to the pipes—which should be thoroughly cleaned beforehand. When the surface is dry, a final coat, about 1 in. thick, should follow. The surface is finally smoothed off with a trowel or by hand. Cold water pipes take longest to dry and it is advisable to treat them during the summer months to ensure that they are dry before the frosts come.

EXHIBITIONS AND CONFERENCES

This list, in chronological order, appears in the last issue of each month. Events noticed for the first time and alterations of dates, places, etc., are indicated by an asterisk (*). For details of events not included below, reference should be made to ENGINEERING, *October 25, page 527, and November 29, page 683. Organisers are invited to send particulars of coming events to the Editor.*

National Boat Show.—Wed., Jan. 1, to Sat., Jan. 11, at Olympia, London, W.14. Organised by the Ship and Boat Builders' National Federation, 205 Regent-street, London, W.1. Tel. REGent 1108.

Problems of Aircraft Production, Sixth Annual Conference.—Thurs., and Fri., Jan. 2 and 3, at The University, Southampton. Theme: "United States and United Kingdom Practice." Organised by the Southampton Section of the Institution of Production Engineers, 10 Chesterfield-street, London, S.W.1. Tel. GROsvenor 5254.

Indian Science Congress Association, 45th Meeting.—Thurs., Jan. 2, to Wed., Jan. 8, in Calcutta. Organised by the Association, 1 Park-street, Calcutta 16, India.

***International Toy Fair.**—Sat., Jan. 11, to Fri., Jan. 17, in Harrogate. Organised by the Harrogate International Toy Fair Ltd., Finsbury-court, Finsbury Pavement, London, E.C.2. Tel. MONarch 8921.

***Microtexts and Microrecording, Symposium.**—Tues., Jan. 14, at Hatfield Technical College, Hatfield, Herts. Applications should be made promptly to the County Technical Librarian at that address. Tel. Hatfield 3282.

International Book Exhibition.—Tues., Jan. 14, to Sun., Jan. 19, in Tokyo. *Representative:* Mr. A. P. Wales, 36-38 Southampton-street, London, W.C.2. Tel. TEMple Bar 8947.

Motor Boat Show, National.—Sat., Jan. 18, to Sun., Jan. 26, at the Coliseum, New York. Organised by the National Association of Engine and Boat Manufacturers, 420 Lexington-avenue, New York City 17.

Convention and Exposition of the National Association of Home Builders, 14th Annual.—Sun., Jan. 19, to Thurs., Jan. 23, at the Coliseum, Chicago. Offices of the Convention: 140 South Dearborn-street, Chicago 3, Ill., U.S.A.

***Furniture Exhibition.**—Mon., Jan. 20, to Sat., Feb. 1, at Earl's Court, London, S.W.5. Organised by F. W. Bridges and Sons Ltd., 641 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

***Nuclear Energy, Symposium on.**—Tues., Jan. 21, at Church House, Westminster, London, S.W.1. Organised, under the auspices of the British Nuclear Energy Conference, by the Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. Tel. BELgravia 3647.

Synoptic Meteorology, World Meteorological Organization's Commission for.—Tues., Jan. 21, to Fri., Feb. 14, at New Delhi, India. Second season, organised by the W.M.O. Secretariat, Avenue de la Paix, Campaigne Rigot, Geneva, Switzerland.

***Hotel and Catering Exhibition, International.**—Wed., Jan. 22, to Fri., Jan. 31, at Olympia, London, W.14. Organised by Hotel and Catering Exhibition (London), Ltd., 623 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 1371.

PROTECTIVE COATINGS

***Protective Coatings, Exhibition.**—Thurs. and Fri., Jan. 23 and 24, at Battersea College of Technology, Battersea Park-road, London, S.W.11. Illustrating research and development in protective coatings and allied corrosion control measures. Organised by the Corrosion Group, Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. Tel. BELgravia 3681.

Eastern Canada Hardware Show.—Mon., Jan. 27, to Thurs., Jan. 30, at the Show Mart, Montreal. Organised by Eastern Canada Exhibitions, Inc., 1600 Berri-street, Montreal, Canada.

***Stationery Trade Fair.**—Mon., Jan. 27, to Fri., Jan. 31, in the Great Hall, Alexandra Palace, London. Organised by the Stationers' Association of Great Britain and Ireland, 6 Wimpole-street, London, W.1. Tel. LANgham 9256.

Canada Farm and Industrial Equipment Trade Show.—Wed., Jan. 29, to Sat., Feb. 1, in the Coliseum, Exhibition Park, Toronto. Organised by Canada Farm and Industrial Equipment Trade Show, Ltd., Wellesley-street East, Toronto 5, Ontario, Canada.

Canadian Hardware Show, 53rd Annual.—Mon., Feb. 10, to Thurs., Feb. 13, in the Canadian National Exhibition Grounds, Toronto. Organised by the Canadian Retail Hardware Association, 290 Merton-street, Toronto 7, Ontario, Canada.

***National Stationery and Book Trades Fair.**—Mon., Feb. 10, to Fri., Feb. 14, in the Royal Horticultural Society's Old Hall in Vincent-square, and New Hall in Greycoat-street, London, S.W.1. Organised by National Newsagent (Exhibitions), Ltd., 149 Fleet-street, London, E.C.4. Tel. CITy 2604.

Power Farming Conference, National.—Tues., Feb. 11, to Thurs., Feb. 13, at the Town Hall, Cheltenham, Glos. Organised by the *Practical Power Farmer*, Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

National Salon of Agriculture, Sixth.—Thurs., Feb. 13, to Sun., Feb. 23, at the Show Mart, Montreal. Agricultural machinery exhibits. Organised by the Salon National de l'Agriculture, 152 Notre Dame-street East, Montreal.

***Motor Show, International.**—Thurs., Feb. 13, to Sun., Feb. 23, at Amsterdam. Organised by the Nederlands Association of the Cycle and Automobile Industry, De Lairessestraat 13, Amsterdam Z, Holland.

***British Toy Fair, Fifth.**—Mon., Feb. 17, to Sat., Feb. 22, at Brighton. Organised by the British Toy Manufacturers' Association, 94 Hatton-garden, London, E.C.1. Tel. CHAncery 9158.

Scottish Dairy Show.—Tues., Feb. 18, to Fri., Feb. 21, at Kelvin Hall, Glasgow. Apply to the general manager, Dairy Show, Corporation of Glasgow, Kelvin Hall, Glasgow, C.3.

Miami International Boat Show, 17th Annual.—Fri., Feb. 21, to Wed., Feb. 26, at Miami. Offices of the Show: 615 S.W. 2nd-avenue, Miami 36, Florida, U.S.A.

Chesapeake Bay Boat Show.—Fri., Feb. 21, to Wed., Feb. 26, at the 5th Regiment Armoury, Baltimore. Offices of the Show: 1006 Cathedral-street, Baltimore 1, Maryland, U.S.A.

"Detroit News" Boat Show.—Sat., Feb. 22, to Sun, Mar. 2, in Detroit. Organised by the Detroit Boat Show, Inc., 16733E Warren-avenue, Detroit 24, Michigan, U.S.A.

***Nice International Fair.**—Sat., Feb. 22, to Mon., Mar. 10, at Nice. Organised by the Foire Internationale de Nice, 8 Place Massena, Nice.

HARDWARE TRADES

***Hardware Trades Fair, Fourth.**—Mon., Feb. 24, to Fri., Feb. 28, in the Royal Horticultural Society's Old Hall, Vincent-square, and New Hall, Greycoat-street, London, S.W.1; also in the Central Hall, Westminster, London, S.W.1. Organised by Universal Exhibitions Ltd., 74 Holland Park, London, W.11. Tel. PARk 7723. (Additional information.)

Recent Advances in Polymer Technology, Conference.—Thurs., Feb. 27, probably at Institution of Civil Engineers, Great George-street, London, S.W.1. Organised jointly by the Institution of the Rubber Industry, 4 Kensington Palace-gardens, London, W.8. (Tel. BAYswater 9101); and the Plastics Institute, 6 Mandeville-place, London, W.1. Tel. WELbeck 5439.

***Cologne International Spring Trade Fair.**—*Household Goods and Hardware:* Fri., Feb. 28, to Mon., Mar. 3; and *Textiles and Clothing:* Sun., Mar. 9, to Tues., Mar. 11, in Cologne. *Agent:* Mr. M. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

Agricultural and Trade Fair, Second.—In March, at Bahrain. Agricultural machinery. Apply to the Director of Agriculture, Bahrain.

***Frankfurt International Spring Fair.**—Sun., Mar. 2 to Thurs., Mar. 6, at Frankfurt. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel. CENtral 5050.

Packaging and Confectionery Machinery Fair (INTERPACK).—Sun., Mar. 2, to Sun., Mar. 9, at Düsseldorf, Germany. Organised by the Nordwestdeutsche Ausstellungs-Gesellschaft m.b.H., Ehrenhof 4, Düsseldorf. *Agents:* John E. Buck and Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

Gas Turbine Conference and Exposition, International.—Tues., Mar. 4, to Fri., Mar. 7, at the Shoreham Hotel, Washington, D.C. Organised by the Gas Turbine Power Division, American Society of Mechanical Engineers, 29 West 39th-street, New York 18.

Oil and Colour Chemists' Association Technical Exhibition.—Tues., Mar. 11, to Thurs., Mar. 13, at the Royal Horticultural Society's New Hall, Westminster, London, S.W.1. Apply to the Oil and Colour Chemists' Association (London Section), Memorial Hall, Farringdon-street, London, E.C.4. Tel. CENtral 2120.

***"Daily Mail" Brighter Homes Exhibition.**—Tues., Mar. 11, to Sat., Mar. 29, at Manchester. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6383.

***Motor Show, International.**—Thurs., Mar. 13, to Sun., Mar. 23, at Geneva. Exhibition offices: 1 Place du Lac, Geneva, Switzerland.

National Association of Corrosion Engineers, Annual Conference.—Mon., Mar. 17, to Fri., Mar. 21, at the Civic Auditorium, San Francisco, Calif., U.S.A. Organised by the Association, 1061 M & M Building, Houston 2, Texas, U.S.A.

***Copenhagen International Technical Fair.**—Fri., Mar. 21, to Sun., Mar. 30, at Copenhagen. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 4951.

Instrument Show, Fourth International.—Mon., Mar. 24, to Sat., Mar 29, at Caxton Hall, off Victoria-street, London, S.W.1. Apply to B and K Laboratories Ltd., 57 Union-street, London, S.E.1. Tel. HOP 4567.

Electrical Engineers' Exhibition, Seventh.—Tues., Mar. 25, to Sat., Mar. 29, at Earl's Court, London, S.W.5. Sponsored by the Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (Tel. LANgham 5927.) Organised by the Electrical Engineers (A.S.E.E.) Exhibition, Ltd., 6 Museum House, 25 Museum-street, London, W.C.1. Tel. MUSeum 3450.

***Radio Aids to Aeronautical and Marine Navigation.**—Thurs. and Fri., Mar. 27 and 28, at the Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. Organised by the Institution's Radio and Telecommunication Section. Tel. TEMple Bar 7676.

Royal Easter Show.—Fri., Mar. 28, to Tues, April 8, in Sydney. Organised by the Royal Agricultural Society of New South Wales, 33 Macquaria-street, Sydney.

***Agricultural Machinery Exhibition.**—Sat., Mar. 29, to Thurs., April 3, at Strasbourg, France. Organised by the Salon International de la Machine Agricole, Union des Exposants de Machines et d'Outillage Agricoles, 95 Rue Saint Lazare, Paris 9.

***"Birmingham Mail" National Trades, Homes and Gardens Exhibition.**—Wed., April 2, to Sat., April 26, in Birmingham. Organised by Herbert Daniel Exhibitions Ltd., 3 Clifford-street, London, W.1. Tel. REGent 8611.

ELECTRONICS & AUTOMATION

Instruments, Electronics and Automation Exhibition.—Wed., April 16, to Fri., April 25, at Olympia, London, W.14. Promoted by the British Electrical and Allied Manufacturers' Assoc., British Industrial Measuring and Control Apparatus Manufacturers' Assoc., British Lampblown Scientific Glassware Manufacturers' Assoc., Drawing Office Material Manufacturers' and Dealers' Assoc., and the Scientific Instrument Manufacturers' Assoc. Organised by Industrial Exhibitions Ltd., 9 Argyll-street, London, W.1. Tel. GERrard 1622.

Brussels Universal and International Exhibition.—Thurs., April 17, to Sun., Oct. 19, at Brussels. Sponsored by the Belgian Government. General inquiries in Britain to be made to the U.K. Commissioner General, Brussels 1958 Exhibition, 83 Baker-street, London, W.1. (Tel. WEIbeck 4420); and space bookings to British Overseas Fairs Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711. See also "Brussels Preview," ENGINEERING, Oct. 25, 1957, page 514.

Home Building Exposition.—Sat., April 19, to Sun., April 27, in the Coliseum, New York. Offices of the Exposition: 250 West 57th-street, New York, U.S.A.

Metal Powder Show.—Mon., April 21, to Thurs., April 24, at the Sheraton Hotel, Philadelphia. Organised by the Metal Powder Association, 130 West 42nd-street, New York City.

***German Industries Trade Fair.**—Sun., April 27, to Tues., May 6, at Hanover. *Agents:* Schenkers Ltd., Royal London House, 13 Finsbury-square, London, E.C.3. Tel. METropolitan 9711.

***Scotland's Own Ideal Home Exhibition.**—Wed., April 30, to Sat., May 17, at Edinburgh. Organised by Herbert Daniel Exhibitions Ltd., 3 Clifford-street, London, W.1. Tel. REGent 8611.

A.S.T.E. Tool Show.—Thurs., May 1, to Thurs., May 8, at the Convention Centre, Philadelphia. Organised by the American Society of Tool Engineers, 10700 Puritan-avenue, Detroit 38, Michigan, U.S.A.

***British Columbia International Trade Fair.**—Thurs., May 1, to Sat., May 10, at Exhibition Park, Vancouver, B.C., Canada. Organised by the Department of Industrial Development, Trade and Commerce, Victoria, B.C., Canada. *Representative:* Agent General for British Columbia, 1 Regent-street, London, S.W.1. Tel. WHItehall 6857.

***Agricultural Machinery and Equipment Exhibition, 38th International.**—Sun., May 4, to Sun., May 11, at the "Plaine de Manoeuvres," Etterbeek, Brussels. Organised by the Société de Mécanique et d'Industrie Agricoles, 29 Rue de Spa, Brussels 4, Belgium.

***Hospital Equipment and Medical Services Exhibition, International.**—Mon., May 5, to Sat., May 10, at Olympia, London, W.14. Organised by Contemporary Exhibitions Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 4951.

***Yorkshire Ideal Homes and Food Exhibition.**—Tues., May 6, to Sat., May 17, at Leeds. Organised by Modern Exhibition Services Ltd., Manchester House, Burnley-road (Luddendenfoot), Halifax.

Mechanical Handling Exhibition and Convention.—Wed., May 7, to Sat., May 17, at Earl's Court, London, S.W.5. Organised by *Mechanical Handling*, Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

***Association of Supervising Electrical Engineers, 1958 Conference.**—Fri., May 9, to Sun., May 11, at the Queen's Hotel, Hastings. Association's headquarters: 23 Bloomsbury-square, London, W.C.1. Tel. LANgham 5927.

***Electronics and Nuclear Energy, Fifth International Congress and Exhibition.**—Sat., May 10, to Sun., May 25, at Rome. Organised by the Rassegna Internazionale Electronica e Nucleare, 14 Via della Scrofa, Rome.

***Business Efficiency Exhibition, 168th Regional.**—Mon., May 12, to Fri., May 16, at the Ice Stadium, Nottingham. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

1958 British Electrical Conference.—Fri. and Sat., May 16 and 17, in Brussels. Supported by the British Electrical and Allied Manufacturers' Assoc.; British Radio Equipment Manufacturers' Assoc.; Cable Makers' Assoc.; Electric Light Fittings Assoc.; Radio Communication and Electronic Engineering Assoc.; Telecommunication Engineering and Manufacturing Assoc.; and Water-Tube Boilermakers' Assoc. Apply to the Conference offices: 36 Kingsway, London, W.C.2. Tel. HOLborn 0502.

Royal Ulster Agricultural Show, 91st.—Wed., May 21, to Sat., May 24, at the Society's show grounds, Balmoral, Belfast. Offices: The King's Hall, Balmoral, Belfast.

Mechanical Engineering Congress, Seventh International.—Mon., June 2, to Fri., June 6, at Scheveningen, Holland. Apply to the British Engineers' Association, 32 Victoria-street, London, S.W.1. (Tel. ABBey 2141); or to the Permanent Secretariat, International Mechanical Engineering Congress, 11 Avenue Hoche, Paris 8e.

Materials Handling Exposition, Eighth National.—Mon., June 9, to Thurs., June 12, at the Public Auditorium, Cleveland. Organised by Clapp and Poliak, Inc., 341 Madison-avenue, New York 17, U.S.A.

***Building Plant Exhibition, 12th.**—Wed., June 11, to Wed., June 18, at Pebble Mill-road, Edgbaston, Birmingham. Organised under the auspices of the Ministry of Works, Lambeth Bridge House, London, S.E.1. Tel. RELiance 7611, ext. 1177.

Chemical and Petroleum Engineering Exhibition.—Wed., June 18 to Sat., June 28, at Olympia, W.14. Sponsored by the British Chemical Plant Manufacturers Association and the Council of British Manufacturers of Petroleum Equipment. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568. (Additional information.)

***British Fair of Industry and Commerce.**—Fri., July 4, to Sat., July 19, at Belle Vue, Manchester. Apply to the exhibition manager, British Fair of Industry and Commerce, Belle Vue (Manchester), Ltd., Belle Vue, Manchester, 12.

Laundry, Dry Cleaning and Allied Trades Exhibition.—Thurs., July 17, to Sat., July 26, at Olympia, London, W.14. Organised by F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

***British Food Fair.**—Thurs., Aug. 28, to Thurs., Sept. 11, at Olympia, London, W.14. Organised by the Food Manufacturers' Federation, Inc., 10 Mount-row, London, W.1. Tel. LEGation 2933.

***Analogy Computation Meeting, Second International.**—Mon., Sept. 1, to Tues., Sept. 9, at Strasbourg, France. Apply to Mr. F. H. Raymond, Association Internationale pour le Calcul Analogique, 138 Boulevard de Verdun, Courbevoire, Seine, France.

***Domestic Equipment Trades Fair.**—Tues., Sept. 2, to Thurs., Sept. 11, at Olympia, London, W.14. Organised by B. C. and D. Trade Exhibitions Ltd., 194-200 Bishopsgate, London, E.C.2. Tel. AVEnue 1444. (Alteration of dates.)

***Handicrafts and Do It Yourself Exhibition, Sixth International.**—Thurs., Sept. 4, to Fri., Sept. 19, at Olympia, London, W.14. Exhibition offices: 24 Store-street, London, W.C.1. Tel MUSeum 9792.

WORLD POWER

***World Power Conference, Sectional Meeting.**—Sun., Sept. 7, to Thurs., Sept. 11, at the Queen Elizabeth Hotel, Montreal. Apply to the secretary, British National Committee, World Power Conference, 201-202 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 3966. *Note:* A Sectional Meeting of the conference will be held in Madrid in 1960; the Sixth Plenary Meeting in Australia in 1962; and a Sectional Meeting in Switzerland in 1964.

***Business Efficiency Exhibition.**—Mon., Sept. 22, to Sat., Sept. 27, at the City Hall, Manchester. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

***Industrial Fuel Efficiency Exhibition.**—Wed., Sept. 24, to Fri., Oct. 3, at Olympia, London, W.14. Organised, in association with F. W. Bridges and Sons, Ltd., by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester 3. Tel. Deansgate 6363.

***Public Works and Municipal Services Congress and Exhibition.**—Mon., Nov. 10, to Sat., Nov. 15, at Olympia, London, W.14. Organised by the Municipal Agency Ltd., 70 Victoria-street, London, S.W.1. Tel. VICtoria 9132.

***Building Trades Exhibition.**—Tues., Nov. 11, to Sat., Nov. 22, at the City Hall, Deansgate, Manchester. Organised by Provincial Exhibitions Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

***International Congress on Combustion Engines.**—Second quarter of 1959, in Germany. Theme: "Diesel Engines and Gas Turbines up to 1,500 h.p.: Current Problems Concerning Their Design, Production, Development and Running on Site." Intending authors of papers should notify the British National Committee by February 1. Apply to the secretary to the national committee, International Congress on Combustion Engines, 6 Grafton-street, London, W.1. Tel. HYDe Park 5107.

Marketing

FINDING NEW PRODUCTS

The news released recently by F. Perkins, the Diesel engine people, of Peterborough, that an entire new division had been created to develop and introduce new products has focused attention on what is becoming a nation-wide problem in engineering. All but the largest companies must look round for new ideas and for opportunities to buy time in the technological race. For many firms this means taking up licences to make here what is new in America, Germany, France and other countries. The same process takes place in the other direction but we are concerned here with the problems involved in finding or buying new ideas rather than in selling them.

Perkins are not alone in setting up special facilities to keep a company's product policy moving. They are large enough to set up a whole division the task of which will be "to develop and introduce" new products. Several other large groups of companies known to us have entrusted one senior director on the main board with the task of new product handling. Quite irrespective of what may come out of research and development, these firms keep a careful watch on anything abroad worth taking up.

But there is much more to a successful product policy than the finding of new ideas. There is a process of sorting and sifting, on technical grounds, on the basis of preliminary market information or on that of company knowledge which is revealed in discussion. Perkins are quite right in assuming that an organisation rather than one director or group of executives is needed to do the work. It has never been easy to get senior people in a company to give concentrated attention to projects extraneous to their normal activities. The chief engineer finds it hard to set aside a day or two each month for the examination of something which his firm do not make and which is perhaps some way outside his own field of intimate knowledge and experience. Likewise, the works manager prefers not to be distracted by having to consider whether something he has never seen can be interleaved into his current production. All executive officers even sales managers have this difficulty Only when a firm has a line and staff organisation can it be said to be in a position to entrust senior people unhindered by daily routine tasks with the type of forward thinking which keeps a firm's product policy moving.

The subsequent note on research projects indicates what Professor Carter considers essential to make a choice between research projects—"economic and managerial thinking of a high order." In some instances engineering firms have turned for advice on product policy to industrial consultants, who have had teams of technical and commercial people whose jobs continuously take them round industry at home and abroad. Some firms specialise in this service and are organised to receive from abroad information on new products and processes. One of the objects is to tap an outside source of information, another no less important is to stimulate thought and action inside the company.

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Picking the Winner

In a thoughtful paper read to the British Institute of Management's national conference last month Professor C. F. Carter said that "effective research management is as much a matter of economics as of natural science." Speaking on "Research—A Management Technique," he considered that "research and development must be related to the financial position and commercial objectives of the firm, and should in turn be reacting on the habits and ways of thinking of other departments." Professor Carter has spent much time studying the part played by good human relations and effective interchange of ideas in the promotion of healthy change within a firm.

The "inspired curiosity of individuals" which did so much to bring about technical progress in the Eighteenth and Nineteenth Centuries, no longer works very effectively. A relatively small proportion of research projects come from a company's research staff—less than a quarter, says Professor Carter—the rest come from sales reports, customers, the pressure to reduce costs or to save some scarce material or type of labour. A great many come from abroad. But, whatever its origins, a new product normally has to be fully investigated before going ahead. Nearly always it is a choice from several for if there are people with lively minds about there will be far more projects put up for consideration than can possibly be used. The size and rate of growth of the market has to be assessed, the reactions of competitors anticipated, the likely production costs worked out. There is also a need to study the reaction of the product on the structure of the company. As Professor Carter points out, "there is no sense in starting something which will obviously be too big to be handled, too expensive to be financed, or too explosive in its reactions on the managerial structure of the company."

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Educate to Sell

Advertisements have appeared recently in the national Press which are essentially educational concerning products in daily use. Rather than tell a snippet of colourful British history or a legend, or a story about the planets, these advertisements tell the story of the various processes in the manufacture of a product.

The third of a series to be inserted by the Steel Company of Wales is entitled *The Birth of a Tin*. It is headed by a photograph of the Margam steelworks and includes a brief description of the various stages in manufacture of the tin-plate, assisted by a flow-sheet type of diagram with brief descriptions of each stage. Then follows a summary of the varied uses to which tin-plate is put.

This type of advertisement could be aimed at the youth of to-day who were born in the war years. It is also likely to interest older people without technical knowledge, who may be in finance, education, management and other professions. It would be interesting to see the results of a reaction test.

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Closer Links for More Sales

The suggestion that "by far the best thing a British Government could do to promote exports to Canada would be to put in hand a transatlantic television cable at the earliest possible date" was made last week by Mr. C. O. Stanley. He pointed out that the reception of American television programmes "has probably done more to swing Canadian trade away from Britain and towards America, than any other single factor." Mr. Stanley is chairman and managing director of the Pye group of companies, who sell telecommunication equipment extensively on the Canadian market. He is therefore an interested party. Yet his contention that a good television outlet from Britain to Canada might "easily double" exports of British consumer goods in the space of a few years is in line with remarks made by members of the Canadian mission on the need for more publicity and advertising from Britain.

In an article published in last week's issue (page 778) we pointed out that remoteness was our principal handicap in Canada. The United States is near, cheap to call on the telephone, quick to visit, even at week-ends. Perhaps in a few years this will apply to Britain also. Meanwhile, Mr. Stanley is quite right. We must use all possible means of getting closer. Television is one, the telephone is another. Mr. Stanley says the cost of the development of submarine transistor amplifiers would not exceed £15 million, i.e., the cost of the trans-atlantic telephone cable. This would be a small price to pay for proximity. But the telephone remains the most immediate prospect of closer contact. We should see to it that its cost is reduced to enable any firm to pick up the receiver and put through a call. It would allay many worries concerning placing orders here.

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Cheaper Air Fares

The air fare structure of the major airlines is still in its experimental stage. At a recent conference of the International Air Transport Association (IATA) it was decided—subject to the approval of governments—that a new "economy service" should be instituted over transatlantic routes. The one-way third-class fare would be £90 compared with the present tourist fare of about £103. The return fare will be 20 per cent. cheaper, at £162. Passengers will have less space and will be fed more simply but their luggage allowance will remain unchanged at 20 kilogrammes. To finance these proposed changes first-class and tourist fares will be raised by £12 10*s*. and £8 10*s*. respectively.

IATA are determined greatly to increase the volume of their business. With the arrival of larger and faster aircraft the new fare levels should yield a good rate of profit. The decision to subsidise the change initially, mainly at the expense of business men, is presumably designed to test the market without incurring heavy traffic losses. One can assume that the airlines' sales-promotional campaign will be heavy and to have conducted the experiment entirely unassisted may have proved too expensive for some of the airlines.

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Canadian Mission Notebook

Members of the Canadian mission now touring this country have visited all principal industrial centres. Their tour, said their leader, Mr. Gordon Churchill, was an "eye-opener." They have been greatly impressed with what they have seen, particularly with the range and quality of some of the goods. It is evident that there is much ignorance of British industry in Canada. Mr. Churchill did not attempt to hide this and pointed out that the best way to make progress was, first, to increase advertising and, secondly, to publicise much more the completion of major projects undertaken in Canada by British firms.

Although some members may enter into definite contracts before their departure this is on the whole unlikely. On the other hand, Mr. Churchill announced that plans for a "follow-through" campaign after their return were now being considered. He did not think the present uncertain business outlook in North America should discourage British companies. They could not expect an increase in preference margins, but neither need they fear that successful sales campaigns would lead to the erection of tariff barriers.

More will be heard about the Canadians' reactions when they have completed their interviewing of the very large numbers of British manufacturers who asked to see them here in Britain. Meanwhile, it is quite clear that the Canadians are favourably impressed; there is keen and widespread interest in their visit on the part of British industry; and enough has been said to indicate that pro-British sentiment is unlikely to cloud their business sense.

Design

PHYSICS IN REACTOR DESIGN

A Pictorial Summary of Elementary Nuclear Concepts

Concluded from page 787

The final sections of Mr. G. W. K. Ford's article on reactor physics are devoted to the following subjects: improved methods of calculating critical size; the reflected reactor and group theories; and the problem of breeding. Previous sections have included an introduction together with a summary of basic nuclear principles (December 6, page 723); a treatment of elementary reactor physics (December 13, page 756); and a detailed study of criticality and the neutron slowing-down process (December 20, page 784). Mr. Ford is Research Manager of the experimental criticality group at the United Kingdom Atomic Energy Authority's establishment at Dounreay. It should be emphasised that the treatment adopted calls for study rather than a single reading.

By G. W. K. Ford, M.B.E., M.A., A.M.I.MECH.E., A.M.I.E.E.

(E) IMPROVED THEORIES FOR CRITICAL SIZE

The mathematical treatment of the phenomena involved in the migration of neutrons by means of a diffusion-process theory does not represent accurately many aspects of the actual events, and more accurate theories have been developed to deal with special features of neutron migration processes. Many of these have produced corrections which may be applied to parameters used in diffusion equations, and a few methods of calculation have been evolved for solving the complete critical size problem by rather different mathematical techniques: the so-called "Monte Carlo" method is an example. It is not intended to deal with these special theories at all in this article, since they are subjects for specialists and usually require electronic calculating machines for their application. Also no more than passing reference will be made to the improved parameters to be employed for refining calculations in which diffusion theory is used, since there are many such considerations and they do not affect the main principles of the treatment discussed here. But it is worth mentioning the fact that with light nuclei the scattering of neutrons is not isotropic: rather there is a pronounced forward scattering effect. This appears in the corrected diffusion equations as an adjusted mean free path, the "transport mean free path," which is always used in the diffusion constant for accurate work.

It may, however, be useful to examine ways in which the diffusion theory may be applied in association with improved mathematical models to provide better forecasts of critical size, and the important matter of using a neutron reflector to surround the reactor core must also be considered.

Continuous Slowing-Down or Fermi Age Model (*Fig.* 32)

The continuous slowing-down model is of great interest in that it illustrates many of the essential features of neutron slowing-down theory and because it has had much use in connection with the design of the earlier reactors. The continuous slowing-down model can only apply if there is a large number of collisions during the slowing-down process, and for this reason is mainly applicable to graphite moderated systems (of the order of 114 collisions) rather than to light and heavy water types (in which the average neutron only makes about 18 and 25 collisions between fission at thermal energies).

The theory is depicted graphically in Fig. 32. All the neutrons arising from fission are assumed to be born within the system at the average energy, E_F, of the fission spectrum, about 2 MeV, and to be slowed down to the most probable energy, E_{TH}, of thermal neutrons, namely 0·025 eV, at which single energy they are assumed to diffuse. The doubly-infinite slab reactor of extrapolated thickness $2a$, as in Fig. 22, is again considered. The essential condition for criticality is the thermal neutron diffusion equation (2) written in part (*d*) of the figure, which can be solved using the thermal neutron diffusion and cross-section data (which is standardised to 0·025 eV) apart from the source term $p\,q_T$. The value of p, the resonance escape probability, is calculated as described above and becomes part of k_∞, but to calculate q_T, the number of neutrons thermalised per cub. cm. of reactor per second, requires a knowledge of the leakage of neutrons during slowing-down.

To calculate the leakage during slowing-down a new parameter q, the slowing-down density, is defined as the number of neutrons per cub. cm. which slow down through the energy level E per second. Consider that portion of the whole neutron population in 1 cub. cm. of reactor volume which have log energies lying between $\ln E$ and $\ln E + \Delta \ln E$, where $\Delta \ln E$ is an infinitesimal interval of $\ln E$ ($\log_e E$, the Naperian logarithm of E, is written $\ln E$ in this section and in Fig. 32 for compactness). The average loss of $\ln E$ per neutron-moderator-nucleus collision is ξ, as already referred to in section D(6): ξ is independent of E, depending only upon the relative masses of the neutron and the moderator nucleus, and is therefore constant over the whole slowing-down energy range (it is readily calculated using elastic billiard-ball collision mechanics. For hydrogen, $\xi = 1{\cdot}000$, for heavier atoms $\xi \simeq 2/(A + \frac{2}{3})$ where A is the atomic weight of the moderator nuclei). Therefore, assuming the continuous slowing-down model, in which the loss of $\ln E$ per collision is sufficiently small that the stepped line in Fig. 31 is adequately represented by the smooth, continuous line drawn through it, the number of collisions required for the average neutron to reduce its kinetic energy from $(\ln E + \Delta \ln E)$ down to $\ln E$ is $\Delta \ln E/\xi$. But within this energy range the number of scattering collisions *per second* per cub. cm. is simply $\Sigma_s\,[\phi\,(\ln E)\,\Delta \ln E]$ (ref. Fig. 16) where $\phi\,(\ln E)$ is defined as the total neutron flux per unit interval of $\ln E$ and therefore $\phi(\ln E)\,\Delta \ln E$ is the neutron flux in the energy range $\Delta \ln E$; Σ_s is the macroscopic scattering cross-section of the moderator material. Hence, the number of neutrons which have their energies reduced *through* the energy *range* $\Delta \ln E$ (and also, therefore, which leave the range at energy E) is given by: (total number of scattering collisions per cub. cm. per second in the neutron population in energy range $\Delta \ln E$) divided by (average number of collisions required to reduce a neutron's energy by $\Delta \ln E$) which is equal to:

$$\frac{\Sigma_s[\phi\,(\ln E)\,\Delta \ln E]}{\Delta \ln E/\xi} = \xi\,\Sigma_s\,\phi\,(\ln E)$$

= number of neutrons crossing energy level E per sec. per cub. cm.

$= q$, by definition.

Defining $n\,(\ln E)$ as the *number* of neutrons per unit $\ln E$ energy interval and $\bar{v}$ as the average velocity of the neutrons in the energy range being considered, then $n(\ln E)\bar{v} = \phi\,(\ln E)$, and $n\,(\ln E)\,\Delta \ln E$ is the number of neutrons in the infinitesimal range $\Delta \ln E$. By the rules of logarithms, $n\,(\ln E)\,\Delta \ln E = n\,(\ln E)\,\Delta E/E$. The number of neutrons in the energy range ΔE is also $n(E)\,\Delta E$ by definition (ref. Fig. 9), and $\phi(E) = n(E)\bar{v}$, where $\phi\,(E)$ is the neutron flux per *unit* energy interval and $n(E)$ is the number of neutrons per *unit* energy interval. Hence, $n\,(E) = n\,(\ln E)/E$ and also $\phi\,(E) = \phi\,(\ln E)/E$. Therefore the slowing-down density may also be written $q = \xi\,\Sigma_s E\,\phi\,(E)$.

If the losses of neutrons from each cub. cm. of the reactor during slowing-down are negligible (for example, in a very large or infinite reactor where B is very small or zero) then q must be constant and equal to q_F, the rate of production of fission neutrons per cub. cm. per second. In this case:

$$\phi(E) = \left(\frac{q_F}{\xi\,\Sigma_s}\right)\frac{1}{E} = \frac{\text{constant}}{E}.$$

This is the origin of the theoretical 1/E spectrum referred to in Figs. 9 and 12, to which the actual slowing-down in a real reactor approximates. In a real reactor, of course, the fission source is not monokinetic and the leakage and absorption losses of neutrons slowing-down may not be negligible.

The formula for q is seen to be plausible on general physical grounds: for a given flux $\phi(\ln E)$, one would expect more scattering, that is, slowing-down collisions, the larger the value of (scattering cross-section, σ_s) × (number of nuclei per cub. cm., N), that is, Σ_s; and that therefore more neutrons will slow-down past a given energy level (that is, q will be larger), the larger the number of collisions and the larger the amount of $(\ln E)$ lost per collision, that is, ξ.

Using these relationships it is now possible to write down a diffusion-theory equation for the neutron population of a small (infinitesimal) energy range $\Delta \ln E$, as shown in part (*a*) of Fig. 32. It is assumed that there is no absorption of neutrons during slowing-down so that the volume-element of the reactor (1 sq. cm. × dx) considered gains neutrons of the given energy range, that is $(\ln E)$ to $(\ln E + \Delta \ln E)$, only from diffusion inwards across its x-boundary *and* birth within itself at rate q_b, and loses neutrons only by diffusion outwards across its $(x + dx)$ boundary *and* death within itself at rate q_d. For the steady state there is no net gain or loss of neutrons of energy in the range $(\ln E)$ to $(\ln E + \Delta \ln E)$ within the element, so we may write the neutron balance equation for the neutron population within this energy range:

$$-\,D\bar{v}\left(\frac{\partial}{\partial x}\,[n\,(\ln E)\,\Delta \ln E]\right)_x - \left\{-\,D\bar{v}\left(\frac{\partial}{\partial x}\,[n\,(\ln E)\,\Delta \ln E]\right)\right\}_{x+dx} + [q\{x, (\ln E + \Delta \ln E)\}\,dx - q\{x, \ln E\}\,dx] = 0 \quad . \quad . \quad . \quad \text{(E) 1}$$

Since by the rules of partial differentiation, $\Delta \ln E$ is constant with respect to variation of n as a function of x on the left-hand side, $\Delta \ln E$ may be taken out of the operator $\frac{\partial}{\partial x}$; and the term in q in the square brackets is simply:

$$\frac{\partial q}{\partial(\ln E)}\,(\Delta \ln E)\,dx.$$

Hence (E) 1 may be re-written:

$$D\bar{v}\,\frac{\partial^2 n\,(\ln E)}{\partial x^2} + \frac{\partial q}{\partial(\ln E)} = 0 \quad . \quad \text{(E) 2}$$

or, since $n\,(\ln E)\,\bar{v} = \phi\,(\ln E)$, and $D = \frac{\lambda_s}{3}$,

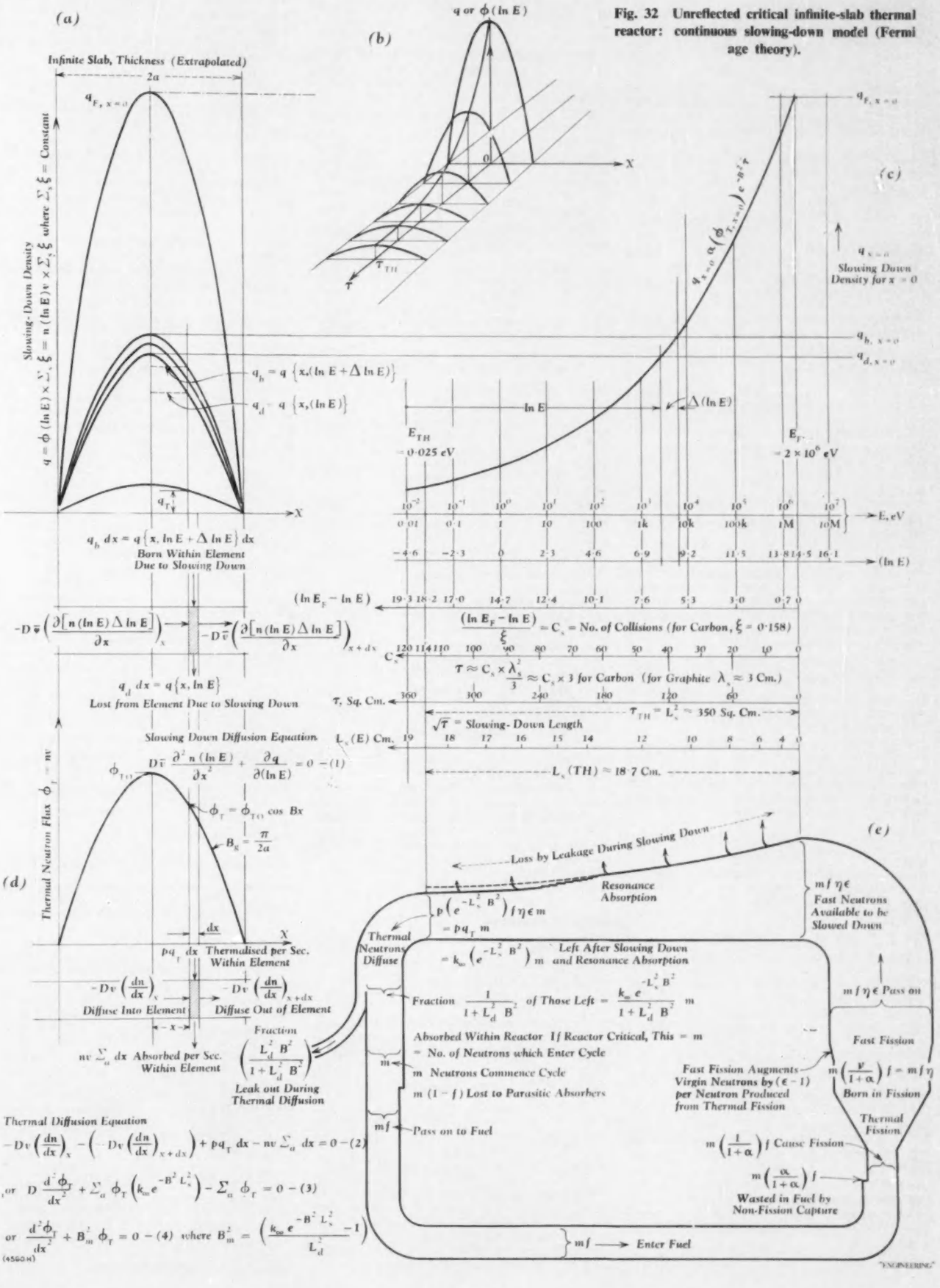
(a)
Infinite Slab, Thickness (Extrapolated)
2a
Slowing-Down Density
Thermal Neutron Flux
Born Within Element Due to Slowing Down
Lost from Element Due to Slowing Down
Slowing Down Diffusion Equation
Thermalised per Sec. Within Element
Diffuse Into Element
Diffuse Out of Element
Absorbed per Sec. Within Element
Leak out During Thermal Diffusion
(b)
(c)
Slowing Down Density for x = 0
Resonance Absorption
(d)
(e)
Loss by Leakage During Slowing Down
Thermal Neutrons Diffuse
Left After Slowing Down and Resonance Absorption
Absorbed Within Reactor If Reactor Critical, This = m
= No. of Neutrons which Enter Cycle
m Neutrons Commence Cycle
m (1 − f) Lost to Parasitic Absorbers
Pass on to Fuel
Fast Neutrons Available to be Slowed Down
Fast Fission Augments Virgin Neutrons by (ϵ − 1) per Neutron Produced from Thermal Fission
Born in Fission
Thermal Fission
Wasted in Fuel by Non-Fission Capture
Enter Fuel
Fast Fission
Pass on
Cause Fission
"ENGINEERING"

Fig. 32 Unreflected critical infinite-slab thermal reactor: continuous slowing-down model (Fermi age theory).

Thermal Diffusion Equation

$$-Dv\left(\frac{dn}{dx}\right)_x - \left(-Dv\left(\frac{dn}{dx}\right)_{x+dx}\right) + pq_T\,dx - nv\,\Sigma_a\,dx = 0 - (2)$$

$$\text{or}\quad D\frac{d^2\phi_T}{dx^2} + \Sigma_a\,\phi_T\left(k_\infty e^{-B^2L_s^2}\right) - \Sigma_a\,\phi_T = 0 - (3)$$

$$\text{or}\quad \frac{d^2\phi_T}{dx^2} + B_m^2\,\phi_T = 0 - (4)\quad \text{where } B_m^2 = \left(\frac{k_\infty e^{-B^2L_s^2} - 1}{L_d^2}\right)$$

(4560.H)

Continuing **Design**

this may be written:

$$-\frac{\lambda_s}{3}\frac{\partial^2\phi\,(\ln E)}{\partial x^2}=\frac{\partial q}{\partial(\ln E)} \quad . \quad (E)\,3$$

Recalling that the slowing-down density q at energy E is everywhere proportional to the neutron flux per unit (ln E) interval for the same energy region, ϕ (ln E), (because q originates from ϕ):

$$\phi\,(\ln E)=\frac{1}{\xi\,\Sigma_s}q=\frac{\lambda_s}{\xi}q$$

and therefore

$$\frac{\partial^2\phi\,(\ln E)}{\partial x^2}=\frac{\lambda_s}{\xi}\frac{\partial^2 q}{\partial x^2} \quad . \quad (E)\,4$$

Equation (E)3 may therefore be written (using (E) 4):

$$-\frac{\lambda_s^2}{3\,\xi}\frac{\partial^2 q}{\partial x^2}=\frac{\partial q}{\partial(\ln E)} \quad . \quad (E)\,5$$

If an important new parameter τ, the Fermi Age, is defined as [see Fig. 32(*c*)]:

$$\tau=\frac{\lambda_s^2}{3}\frac{\ln E_r-\ln E}{\xi}$$

$$=\frac{\lambda_s^2}{3}\times\begin{pmatrix}\text{No. of collisions slowing-down}\\ \text{from fission energy } E_r \text{ to } E\end{pmatrix}$$

. . . (E) 6

it is evident that $\Delta\tau=-\frac{\lambda_s^2}{3}\frac{\Delta\ln E}{\xi}$. (E) 7

So that (E) 5 becomes $\frac{\partial^2 q}{\partial x^2}=\frac{\partial q}{\partial\tau}$ (E) 8

This is the Fermi Age Equation, and making the assumption that

$$q=X(x)\,T(\tau) \quad . \quad . \quad (E)\,9$$

where $X(x)$ and $T(\tau)$ are separate functions of x and τ, (E) 8 may be solved by the usual method for solving partial differential equations with separable variables. Thus, differentiating (E) 9 with respect first to x (twice) and then to τ (once), and substituting in (E) 8 gives:

$$\frac{1}{X}\frac{\partial^2 X}{\partial x^2}=\frac{1}{T}\frac{\partial T}{\partial\tau} \quad . \quad . \quad (E)\,10$$

in which the left-hand side is a function of x only, and the right-hand side is a function of τ (or energy E) only.

Since either x or τ can take on any finite value independently, the only way in which this equality can be preserved for all values of x and τ is for each side to be constant. It will be seen that this constant is $-B^2$, the (geometric) buckling, because then:

$$\frac{d^2X}{dx^2}+B^2X=0 \quad . \quad (E)\,10(a)$$

or $X=A_1\cos\frac{\pi x}{2a}=A_1\cos Bx$

(because when $x=0$, $\frac{\partial X}{\partial x}=0$ from symmetry, and when $x=a$, $X=0$, since then $q=0$ because $\phi\,(\ln E)=0$; $B=\frac{\pi}{2a}$ as before; A_1 is a constant). Taking the right-hand side of equation (E) 10:

$$\frac{1}{T}\frac{dT}{d\tau}=-B^2 \quad . \quad . \quad (E)\,10(b)$$

Therefore $T=A_2e^{-B^2\tau}$ . . (E) 11

Hence $q=q_r e^{-B^2\tau}\cos Bx$. (E) 12

where A_1 and A_2 have been combined into q_r, the slowing-down density at $x=0$, $\tau=0$. This is the rate of production of fission neutrons, which is directly related to the thermal neutron flux at the position $x=0$, namely ϕ_{T0}, as follows:

$$q_r=(\phi_{T0}\,\Sigma_a)\,f\,\eta\,\epsilon \quad . \quad (E)\,13$$

since for every neutron absorbed in the reactor $f\,\eta\,\epsilon$ are produced by fission, and $\phi_{T0}\,\Sigma_a$ gives the rate of absorption of thermal neutrons due to all processes.

Thus $q=\phi_{T0}\,\Sigma_a\,f\,\eta\,\epsilon\,e^{-B^2\tau}\cos Bx$. (E) 14

But $\phi_{T0}\cos Bx=\phi_T$, the thermal neutron flux at x, therefore

$$q=\phi_T\,\Sigma_a\,f\,\eta\,\epsilon\,e^{-B^2\tau} \quad . \quad (E)\,15$$

We require the slowing-down density at $E_T=0{\cdot}025$ eV, namely q_T, in order to obtain the source term, pq_T, for the thermal neutron diffusion equation. At $E=0{\cdot}025$ eV, $\tau=L_s^2$ where L_s is the slowing-down length for fission to thermal.

Hence,

$$pq_T=\phi_T\,\Sigma_a\,p\,f\,\eta\,\epsilon\,e^{-B^2L_s^2} \quad . \quad (E)\,16(a)$$

and since $p\,f\,\eta\,\epsilon=k_\infty$, the source term is:

$$pq_T=k_\infty\,\Sigma_a\,e^{-B^2L_s^2}\,\phi_T \quad . \quad (E)\,16(b)$$

The thermal neutron equation [Fig. 32(*d*)(2)] can now be completed:

$$\frac{d^2\phi_T}{dx^2}+\frac{\Sigma_a}{D}(k_\infty\,e^{-B^2L_s^2}-1)\,\phi_T=0 \quad (E)\,17$$

which is solved for precisely the same boundary conditions as in Fig. 23: since the curvature of distribution, that is, the buckling (B) for $\phi\,(\ln E)$, q and ϕ_T must all be the same on account of the geometry, that is:

$$\frac{\partial^2\phi\,(\ln E)}{\partial x^2}\Big/\phi\,(\ln E)=\frac{\partial^2 q}{\partial x^2}\Big/q=\frac{d^2\phi_T}{dx^2}\Big/\phi_T=-B^2 \quad (E)\,18$$

So

$$\frac{d^2\phi_T}{dx^2}+B^2\,\phi_T=0 \quad . \quad (E)\,19$$

Comparing (E) 19 with (E) 17:

$$B^2=\frac{(k_\infty\,e^{-B^2L_s^2}-1)}{L_d^2} \quad . \quad (E)\,20$$

which is the critical equation for the Fermi Age model.

The significance of the various terms in the reactor cycle is shown in Fig. 32(*e*).

(F) THE REFLECTED REACTOR AND GROUP THEORIES

(1) The Reflected Reactor: One-Group Theory (*Fig.* 33)

Most practical reactors are provided with a reflector, which results in a considerable saving of fissile material investment. The calculation of the critical size with a reflector is quite easy using the simplest of the available theories, namely the one-group theory, but becomes progressively more difficult as attempts are made to improve the mathematical model.

To calculate the critical size for an infinite-slab reactor using one-group theory merely entails a slight alteration to the boundary conditions for the core diffusion equation of Figs. 22 and 23 using the diffusion equation for a non-multiplying diffusive medium derived in Fig. 20. This is illustrated graphically in Fig. 33. Two homogeneous reactors (infinite slabs) are considered, made of the same fissile-material—moderator mixture, the top reactor, (*a*) being bare, the other, (*b*), reflected by an "infinitely" thick reflector on both sides made of the pure moderating material as used for the core itself. The diffusion length in both core and reflector is assumed to be L for simplicity. The diffusion equation for the bare reactor is as before:

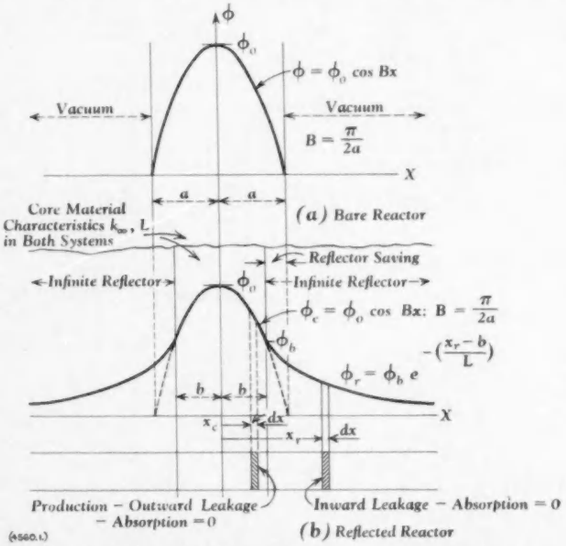

Fig. 33 Reflected infinite-slab reactor: one-group theory.

$$\frac{d^2\phi}{dx^2}+\frac{(k_\infty-1)}{L^2}\phi=0 \quad . \quad (F)\,1$$

so that the buckling

$$B_m=\frac{k_\infty-1}{L^2}=\frac{\pi}{2a}=B_g \quad . \quad (F)\,2$$

and the flux distribution is given by

$$\phi=\phi_0\cos Bx. \quad . \quad . \quad (F)\,3$$

The reflected reactor core is made of the same material mixture, so that B_m is unaltered. The diffusion equations for the core and the reflector are:

Core: $\frac{d^2\phi_c}{dx^2}+\frac{(k_\infty-1)}{L^2}\phi_c=0$

(compare Fig. 22) (F) 4

Reflector: $\frac{d^2\phi_r}{dx^2}-\frac{1}{L^2}\phi_r=0$

(compare Fig. 20) (F) 5

The boundary conditions for the solution of these equations are simply that the neutron flux ϕ_b is the same at the boundary ($x=b$) in both core and reflector, and that the diffusion current flowing out of the core at $x=b$ is the same as that flowing into the reflector at $x=b$. The usual symmetry condition applies to the core, that is $\left(\frac{d\phi_c}{dx}\right)_{x=0}=0$. The solutions of the equations are therefore:

core: $\phi_c=\phi_0\cos Bx$ . . . (F) 6

where B is $\frac{\pi}{2a}$ as before, since B_m is unchanged and therefore B_g must be the same for criticality.

Reflector: $\phi_r=\phi_b\,e^{-\frac{(x_r-b)}{L}}$ . . (F) 7

Applying the first of the boundary conditions:

$$(\phi_c)_{x=b}=(\phi_r)_{x=b} \quad . \quad . \quad (F)\,8$$

so

$$\phi_0\cos Bb=\phi_b \quad . \quad . \quad (F)\,9$$

Applying the second condition:

$$-D\left(\frac{d\phi_c}{dx}\right)_{x=b}=-D\left(\frac{d\phi_r}{dx}\right)_{x=b} \quad (F)\,10$$

(since D has been assumed the same for both core and reflector, this is equivalent to saying that the flux gradient does not change in crossing from core to reflector).

From which:

$$\phi_0\,B\sin Bb=\phi_b\left(\frac{1}{L}\right) \quad . \quad (F)\,11$$

Dividing (F) 11 by (F) 9 gives:

$$B\tan Bb=\frac{1}{L} \quad . \quad . \quad (F)\,12$$

which is the criticality condition,

or

$$\tan\left(\frac{\pi}{2}\frac{b}{a}\right) = \frac{1}{BL} = \frac{L}{\sqrt{k_\infty - 1}}\frac{1}{L} = \frac{1}{\sqrt{k_\infty - 1}} \quad \ldots \quad \text{(F) 13}$$

It is seen that if k_∞ is close to unity, then $\frac{b}{a}$ is also close to unity: if k_∞ is as large as 2, $\tan\left(\frac{\pi}{2}\frac{b}{a}\right) = 1$ so that $\frac{b}{a} = \frac{1}{2}$. This demonstrates why a small reactor, which is small because it has a high value of k_∞, is so much reduced in size by a reflector: in a large reactor the reflector savings, though important, are not so pronounced because k_∞ is closer to unity.

(2) The Multi-Group Theories

Just as the one-group theory for a bare reactor does not take proper account of the leakage into space of the slowing-down neutrons, so the one-group theory for the reflected reactor does not adequately account for the flow of neutrons during slowing-down from the core into the reflector; nor does it account for the slowing-down (and back-flow into the core during slowing-down) of these fast and epi-thermal neutrons within the reflector. It is not mathematically practicable to deal with this problem by means of an infinite series of infinitesimal energy-groups ($\Delta \ln E \to 0$) as in the Fermi Age treatment for the bare reactor, so that resort is made to a number of finite-width energy-groups of neutrons for each of which two diffusion equations may be written down, one for the core, one for the reflector; and, provided appropriately averaged cross-sections for the nuclear processes may be inserted, these may be solved as sets of differential equations by the usual methods to provide the criticality condition.

The simplest of the multi-group-theories is the two-group-theory, in which all the neutrons being slowed-down are treated as one group and the thermal neutrons are treated as the other. It is assumed that there is no absorption in the normal sense for neutrons of the "fast" group: but a "slowing-down cross-section", Σ_1, is defined which accounts for the loss of neutrons from the elemental volume due to the thermalisation of neutrons. The source term for the fast group is given by the absorption term for the thermal group multiplied by k_∞, which also automatically accounts for the resonance absorption, which really takes place within the fast group but which does not appear explicitly in the equation. To illustrate these points the following core equations are given:

$$\text{Fast group: } D_1\frac{d^2\phi_1}{dx^2} - \Sigma_1\phi_1 + k_\infty\Sigma_{a2}\phi_2 = 0$$

$$\text{Thermal group: } D_2\frac{d^2\phi_2}{dx^2} - \Sigma_{a2}\phi_2 + \Sigma_1\phi_1 = 0$$

where the suffixes 1 and 2 refer to the fast and thermal neutrons respectively. If there is a reflector, a similar pair of equations is written down for the fast and thermal groups in the reflector, but the $k_\infty\,\Sigma_a\,\phi_2$ term will not appear because there is no fission in the reflector, and Σ_a will have a very different value.

The four simultaneous differential equations which thus arise in the two-group theory of the reflected reactor can be dealt with by normal manual calculation methods, and this is also just about true of the somewhat better three-group theory for which typical group choices are indicated in Fig. 12; but beyond three groups it is essential for economic working to resort to high-speed computing machines for the solution of the sets of equations, and is desirable even for two groups if much work is to be done with a given system. In practice anything up to 32 groups or more are used in such calculations, but a limit is set to the accuracy and usefulness of these more sophisticated calculations by the availability and accuracy of nuclear cross-section data from which to form the appropriate group-constants, which will, in general, be more complex than in the two-group equations. For example, in the three-group calculation it is usual to include in the epithermal group a "real" absorption term in addition to the slowing-down "absorption" term, and account is also taken of the neutron production from fission in the epithermal group. It is evident, therefore, that much thought must be given to choosing the boundaries of the neutron groups and to the appropriate selection and averaging of the nuclear data.

(G) BREEDING

The Breeding Ratio (*Fig.* 34)

Finally, it is of interest to examine the meaning of the term "breeding ratio," which is a factor of fundamental importance in the selection of economic reactor designs. It is best understood with the aid of a reactor cycle diagram but with slightly modified terms to suit the definition.

The breeding ratio R_B is defined as the number of fissile nuclei generated in fertile material per fissile nucleus consumed.

The breeding ratio may be determined either for a complete reactor system, or for portions of a reactor if the performance of different features is to be assessed, for example the U238 breeder-reflector and the U238-Pu breeder-core in a fast power reactor. Here it is considered as an over-all figure.

The following quantities are defined:

- α = ratio of non-fission capture to fission capture in fuel
- ν = number of neutrons per fission of fuel nucleus (fast and/or thermal fission)
- ν' = number of neutrons per fission of U238 nucleus (fast fission only)
- F = number of neutrons which cause fission in U238 per fission of fuel nucleus
- $\mathscr{L}$ = number of neutrons which leak out of reactor per fission of fuel nucleus
- A = number of neutrons which are absorbed in parasites per fission of fuel nucleus
- P = number of neutrons which are absorbed in U238 to form Pu, per fission of fuel nucleus.

Let n neutrons enter the cycle and cause fission of fuel, producing νn neutrons. Following the cycle round in Fig. 34 it is seen that eventually $(\alpha + 1)\,n$ neutrons have to be absorbed by fuel (U235 or Pu) if n neutrons are to cause fission and keep the cycle repeating, so that

$$(\alpha + 1)n = \nu n - Fn + \nu' Fn - \mathscr{L} n - An - Pn.$$

Therefore

$$R_B = \frac{P\,n}{(\alpha + 1)\,n} \text{ (by definition)}$$

$$= \frac{\text{Number of fissile nuclei formed}}{\text{Number of fissile nuclei consumed}}$$

$$= \frac{(\nu - 1) + F(\nu' - 1) - \alpha - A - \mathscr{L}}{(1 + \alpha)}.$$

Notice that fissile nuclei are consumed by both fission and non-fission capture in fuel.

It is of interest to examine this formula to see why it is that the fast-neutron reactor offers much higher values of R_B than are possible in a thermal system:

(*a*) ν may be marginally higher for fast fission;
(*b*) F is larger in fast than in thermal systems;
(*c*) for fast fission α is low (see Fig. 11);
(*d*) A is smaller in a fast reactor because
  (i) the volume of fuel is much larger as compared with the volume of structure (moderator and coolant) than in a thermal reactor;
  (ii) all cross-sections are low for fast neutrons, and just as α is smaller in a fast reactor, so the structure cross-sections are relatively smaller in relation to the fission cross-section;
(*e*) $\mathscr{L}$ will be rather larger in a small fast-reacting system as compared with a large thermal system, but is off-set by (*a*) to (*d*).

Conversion ratios may vary between about 0·7 in a natural-uranium reactor to almost 2 in a fast power breeder. If R_B is greater than unity the reactor will produce more fissile material than it consumes. It is of interest to see how long it will take for the initial fuel investment to be doubled.

If the specific power of the breeder reactor is W watts per gramme of fuel invested, then $W \times 3{\cdot}1 \times 10^{10}$ fissions per gm. per second are taking place. Then $W(1 + \alpha) \times 3{\cdot}1 \times 10^{10}$ atoms of fuel per second are being consumed. For each atom consumed, R_B atoms of new fissile material are formed, so that a net gain of $(R_B - 1)(1 + \alpha)\,W \times 3{\cdot}1 \times 10^{10}$ atoms per second of fissile material results. Each gm. of fuel (Pu 239, say) contains $\frac{6{\cdot}023 \times 10^{23}}{239}$ $= 2{\cdot}52 \times 10^{21}$ atoms. Therefore, if the time required to produce a net gain of one gm. of plutonium is t days

$$(R_B - 1)(1 + \alpha)\,W \times 3{\cdot}1 \times 10^{10} \times 24 \times 3{,}600 \times t = 2{\cdot}52 \times 10^{21}$$

$$\text{So} \quad t \simeq \frac{10^6}{W(R_B - 1)(1 + \alpha)} \text{ days.}$$

If α is assumed small compared with unity, and if R_B is assumed even as large as 2, it is seen that to double the fuel content of a fast reactor requires $\frac{10^6}{W}$ days, which means that W must be in the region of 1,000 (1 kW per gm. of fuel) if reasonable doubling times are to be attained. No account has been taken of the fuel held up in processing, and this might easily call for a doubling of the power rating to achieve the same investment doubling time. In this respect some types of thermal-neutron reactor using the thorium-uranium (Th232-U233) cycle may compete because although their breeding ratio may be much smaller than is attainable in a fast system (say, $R_B \simeq 1{\cdot}1$ instead of $\simeq 2$), it is possible in some designs to secure a much higher fuel rating (say 10 times) than attainable in a fast reactor as at present conceived. Coupled with continuous chemical processing to reduce fuel hold-up, such systems may compete economically with the fast fission reactor cycles through the combined effects of an only slightly longer fuel-doubling time and a much smaller critical fuel investment (say, 10 times smaller).

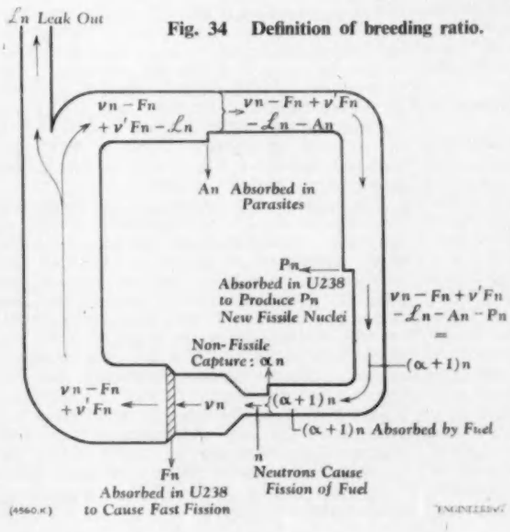

Fig. 34 Definition of breeding ratio.

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A list of references to standard works on nuclear physics and nuclear reactor theory is given on the following page:

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The Elements of Nuclear Reactor Theory, by S. Glasstone and M. C. Edlund (MacMillan and Company, Limited).

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Nuclear Physics in Photographs, by C. F. Powell and G. P. S. Ochialini (Oxford University Press).

Source Book on Atomic Energy, by S. Glasstone (MacMillan and Company, Limited).

Data in the figures and text has been taken from the above works *inter alia*, but in addition the data in the following figures is acknowledged.

Fig. 8: "Determinations of Fission Quantities of Importance to Reactors," R. B. Leachman (Paper P592, Proceedings of 1955 Geneva Conference, Vol. 2: *Physics; Research Reactors*).

Fig. 10: "Summary of Data on the Cross-Sections and Neutron Yields of U233, U235 and Pu239," by J. A. Harvey and J. E. Sanders (*Progress in Nuclear Energy*, Series I, *Physics and Mathematics*, Vol. 1, Chapter I).

Fig. 11: "Some Aspects of Atomic Power Development in the U.S.S.R.," by I. V. Kurchatov.

Reprints of

Physics in Reactor Design

The article Physics in Reactor Design, by Mr. G. W. K. Ford, is to be reprinted as a booklet. Copies may be ordered from ENGINEERING, 35-36 Bedford-street, London, W.C.2, price 4*s*. post free.

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PAPERS FOR C.I.M.A.C.

The Fifth International Congress on Combustion Engines will be held in Germany in the second quarter of 1959. The theme will be "Diesel Engines and Gas-Turbines up to 1,500 h.p.: Current Problems Concerning Design, Production, Development and Running at Site."

It is hoped that, as at Zurich, the United Kingdom will make a notable contribution. Will intending contributors please send to the Secretary of the British National Committee, C.I.M.A.C., 6 Grafton-street, London, W.1, not later than February 1, 1958, the following particulars:—

1. Name, appointment and qualifications for the chosen subject.

2. The title of their paper, accompanied by a simple resumé and a synopsis not exceeding two typed pages complete with a list of probable figures, graphs and tables attached. This should be sufficiently detailed to indicate the likely scope of interest of the paper within the framework of the Congress theme.

The attention of intending authors of papers is particularly drawn to the following rules laid down by the C.I.M.A.C. Permanent Committee at their recent meeting in Paris: 1. All papers containing advertising, commercial or purely descriptive matter will be excluded systematically. 2. Papers will be accepted only if they contain *new* matter on the title subjects.

Authors whose synopses are approved by the Permanent Committee will be so advised in March, 1958. Any further inquiries should be addressed to the Secretary, British National Committee at the above address.

THE AIR-CYCLE HEAT PUMP

A Simple Machine for Space Heating

By K. H. Hunt, M.A., A.M.I.MECH.E.*

It is quite feasible to use air as the working fluid in a heat pump. The theory of the cycle has been presented by several writers, but, so far as the author is aware, there is no significant example of its application to normal air conditioning except where there are other special requirements. The following reasons may well account for the overwhelming preference for the vapour compression refrigeration cycle: (1) Normal refrigerator components and techniques may easily be adapted for heat pumps. (2) The efficiency of the cycle approaches fairly closely to the Carnot efficiency. There are numerous examples of excellent installations operating with high performance ratios using one or other of the usual refrigerants in a vapour compression cycle.

Performance ratio is defined as

$$\frac{\text{Quantity of heat delivered}}{\text{Heat equivalent of energy input}}$$

So long as this is greater than unity, the heat pump is performing with greater thermal efficiency than direct heating. Performance ratio is sometimes referred to as "reciprocal thermal efficiency." The irreversible loss of thermal potential, which is inevitable in a furnace, is greatly reduced in a heat pump.

The processes in the heat exchangers used with an air-cycle heat pump all take place in the gas region, and therefore have not the advantages of isothermal evaporation and condensation within the confines of the "wet" region. In comparison, the larger temperature range of the air cycle prevents its efficiency from being so close to the Carnot efficiency. Furthermore the continuous-flow compressor and expander have isentropic efficiencies which fall well short of 100 per cent., which reduces the performance ratio considerably, a fact that of itself need not be of any real consequence, because the air which is carried through the heat pump cycle is the same air as that used for ventilating and conditioning the building. There are several ways of arranging this, and a good circuit is shown in Fig. 1.

The performance of the unit can no longer be expressed so simply, because the heat pump uses the heat which, for any ordinary heating process, would be wasted in the air rejected to the atmosphere at T_4. The performance ratio, therefore, does not tell the full story; the "advantage over direct heating" does. For a closed cycle arrangement these two terms are identical, but for a circuit such as that shown in Fig. 1 they are very different.

The author does not claim to make any innovations, but merely advocates a shift of emphasis. The air-cycle heat pump can be useful where substantial air heating is demanded and where there is to be little, if any, recirculation (see Fig. 2). Low atmospheric temperatures give rise to low values of T_7 and, generally speaking, ice will be deposited in the expander if T_7 falls lower than 32 deg. F. It is with this limitation in view that the dotted "contour" lines (of constant T_7) are plotted in Fig. 2. Notwithstanding a liberal allowance for practical shortcomings in the heat exchangers and rotating machines, an advantage of nearly 3 may be attained for the data of this arrangement. Even though a vapour compression unit may give better results than this, there is still a marked improvement over direct heating.

Humidity control is common to all air conditioning arrangements, whatever the source of heat. To a reasonable approximation, therefore, the energy quantities involved are identical for both, and a comparison on the basis of dry air is justifiable.

Photo-copies of the full paper of which the above is a digest are obtainable from the Publisher: ENGINEERING, 35 & 36 Bedford-Street, London, W.C.2, price 20*s*. each, post free.

• Senior Lecturer in Mechanical Engineering, University of Melbourne.

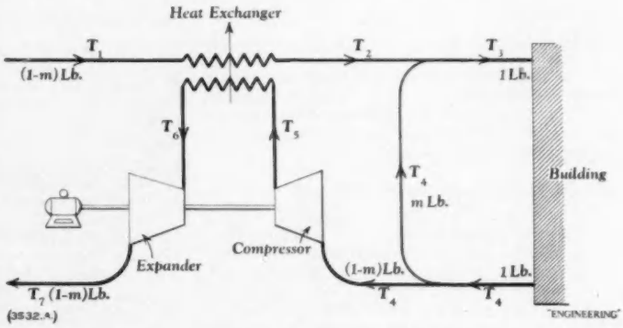


Fig. 1 Operating arrangement for air-cycle heat pump for space heating. Recirculation of a variable amount is included.

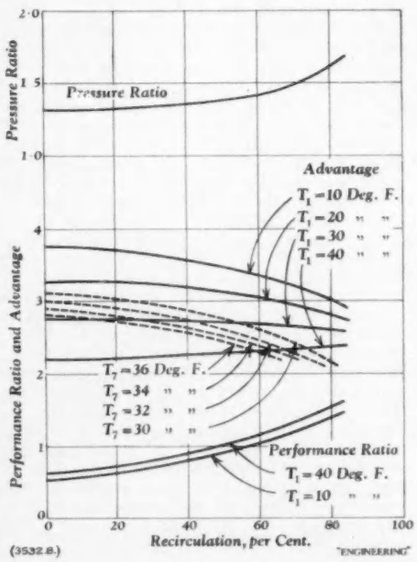


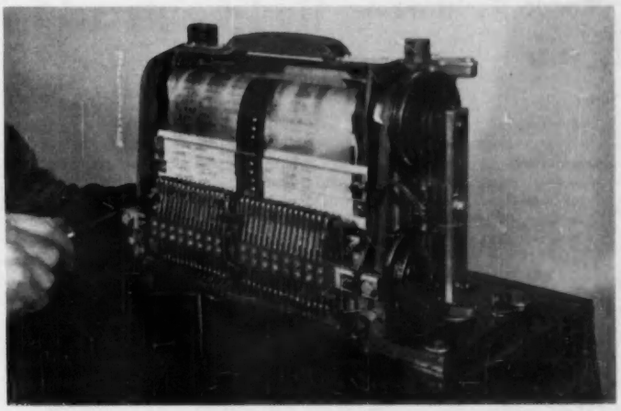
Fig. 2 Performance figures for the arrangement shown in Fig. 1: T_2 = 75 deg. F.; T_3 = 65 deg. F.; $(T_6 - T_1) = (T_5 - T_2)$ = 40 deg. F. Isentropic efficiency assumed to be 85 per cent.

★ ★ ★

DRAWING PARALLEL LINES

J. C. Neville Limited, 24 Priests-bridge, London, S.W.14, are now marketing the Roll Ruler, which is designed to reduce the time involved in drawing a series of parallel lines. It consists of a transparent rule attached to a rolling cylinder, the latter being marked with a helical index. After the first line is ruled, the cylinder is rolled down the surface of the board until the required interval is indicated on the helical markings.

PIANOLA SIGNALLING ON THE TUBE



London Transport will soon use wholly automatic signalling for the in-town parts of the Northern Line of the Underground Railways. Programme machines will operate the signals. They will replace the present manual signalling carried out from three signal cabins at Kennington, Camden Town, and Euston. There is a daily schedule of 900 trains.

The illustration shows a programme machine. Two 8 in. rollers carry a plastic band that has the complete day's service represented on it by a system of holes. Each row of holes will represent one train—with its timing, code number, destination, and route (via Charing Cross, or via City). The plastic bands are 8 ft. long and resemble pianola rolls. An electronic eye positions the band for each train and a comb of 32 steel feelers scans one line of holes. The feelers meeting holes close electrical contacts. These actuate all the correct signalling, point, and safety interlocking movements for the routing of a particular train. The machine rewinds itself during the night.

Where branches of the Northern Line fan out, the programme machine will send each train on its correct way; where branches come together, the machine will signal trains through from each side in their time table order. Should a train from one branch be late, the machine will send a train from another branch forward. But it will "remember" to dispatch the late train as soon as it arrives and the line is free. If trains are running late or not in accordance with the destination shown on the platform indicators, the machine will sound a warning buzzer to the supervising staff. Push buttons will allow manual signalling in the event of there being a delay or breakdown.

The first stage of the changeover will take place on January 15. There will be ten programme machines. Supervision will be from a regulating point at Leicester Square, where a duplicate of each of the programme machines will be installed with an illuminated diagram of the line. The new signalling will begin at Kennington. At this point the machines will be put behind a glass window so that the public can see them working. The changeover will take place at Camden Town and Euston during 1958. Normally the small supervision staff will not have to intervene in train operations.

STABILITY OF FORK-LIFT TRUCKS

We give below a summary of a lecture on "Industrial Fork Truck Stability" given in London recently by Mr. O. S. Carliss, chairman of the Industrial Truck Association of the United States, in which he outlined the work carried out in the United States during the past four years in an effort to produce recommended stability standards for fork-lift trucks up to 10,000 *lb. capacity.*

In 1953, the A.S.A. Standard for trucks specified a minimum stability factor of 1·25 with the mast vertical. However, that was not current practice, and the coefficients were increased to 1·4 on many trucks at the instigation of the manufacturers themselves.

Initial investigations by the Industrial Truck Association to establish a new standard were first made by studying various accidents which had occurred, and many observations were made on truck operation, covering lifting motions, acceleration rates, and deceleration rates when travelling round constant radii where centrifugal forces come into play, giving quite different approaches to the stability question (which had been originally considered only in relation to stacking).

Motion pictures were taken of all these various movements and it was found that transporting loads at high speed could result in losing the load if brakes were applied suddenly. It was also found that the loss of side stability was responsible for the greatest number of accidents.

Following a careful study of the results of these tests it was decided that four tests were desirable, two for longitudinal stability (one in the travelling position and one in the stacking position) and two for lateral stability. Considerable thought was given as to how to correlate these four conditions of truck operation, and an endeavour was made to supply mathematical solutions to the stability problem. During tests it had been established that considering the constant wheelbase, an increase of longitudinal stability appeared to decrease lateral stability until the truck became unsafe even when it was being operated with a load in the unelevated position. This was soon confirmed by the mathematical investigation.

As already stated, four conditions of test were suggested:—(1) longitudinal with the load fully elevated; (2) longitudinal with mast tilted rearward and load in transporting position; (3) lateral with the load elevated; and (4) lateral with the truck empty, forks lowered and mast tilted rearward.

The accompanying illustrations indicate graphically the four conditions:—(Fig. 1) A vertical resultant obtained by considering values of the load and truck weight; the truck can be tipped through A deg. before upsetting occurs. (Fig. 2) Vertical load from the weight of the truck and horizontal force induced into the load by deceleration. The angle B deg. formed by the normal to the resultant of the above forces passing through the point of drive wheel contact with the horizontal plane. (Fig. 3) Allowable horizontal displacement of the load forming an angle C deg. when the truck is tipped about the plane XY. (Fig. 4) Truck weight and centrifugal force induced when truck is negotiating radii at speed; the normal of the resultant of these two forces forms an angle of D deg. with the horizontal plane through the line UV.

If a platform is provided tiltable about one edge, this facilitates the comparison of stability qualities between any trucks on the basis of the four above conditions, if limiting angles are agreed upon for these conditions. It will be appreciated that this method of testing overcomes any problems of mast deflection, frame deflection, tyre deflection and tyre inflation pressures.

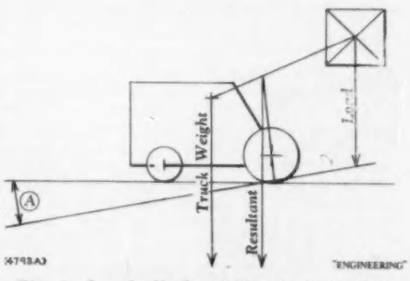


Fig. 1 Longitudinal stability, load elevated.

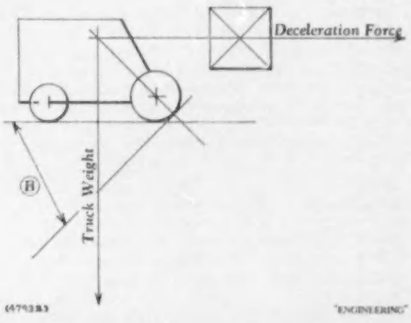


Fig. 2 Longitudinal stability, mast tilted rearwards and load in transporting position.

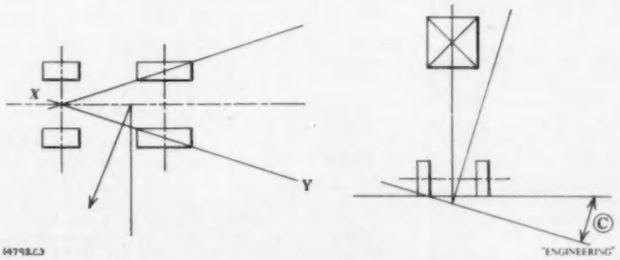


Fig. 3 Lateral stability, load elevated.

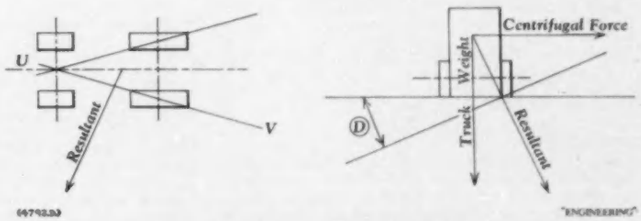


Fig. 4 Lateral stability, truck empty, forks lowered.

Book Reviews

PROCESSING SOLIDS

Chemical Engineering Practice. Vol. 3, Solid Systems. Edited by HERBERT W. CREMER and TREFOR DAVIES. *Academic Press Incorporated, 111 Fifth-avenue, New York 3, N.Y., U.S.A.* (13.30 dols.); *Butterworths Scientific Publications, 88 Kingsway, London, W.C.2.* (95*s.*)

The physical processing of solid materials—their crushing, grinding, screening, grading, classifying, mixing, storage and handling, and finally the rather special problem of removing solid particles from gases are all dealt with at length in this work. These processes have been claimed to constitute one of the traditional " unit operations " of the chemical engineer, although most of the industrial applications are to be found in the mining and metallurgical industries, rather than in the orthodox chemical industry. Nowadays the term " process industries " is being used for any industry in which the constitution of materials is changed to give a product of commercial value, and chemical engineering has acquired a broader conception as the engineering of the process industries. At the same time the recognition of chemical engineering as a university subject suitable for undergraduate study and post-graduate research has been accompanied in the teaching courses by a concentration on those topics which can be studied by mathematical-analytical methods. Since the whole problem of solids handling is notoriously difficult from the standpoint of analysis of this type, crushing, grinding and associated topics have been somewhat neglected by the teachers who will certainly welcome the appearance of a book which they can commend to the students as containing all they are likely to need.

The title of this series of books is " Chemical Engineering Practice " and appropriately enough the authors of the various sections are in the main drawn from industrial concerns famous for the manufacture of machinery and plant of the type described. In spite of what has been written above regarding the neglect of the subject in many university courses, the sections on the principles of crushing and grinding, on the methods of sizing analysis and on the mechanics of pulverisers are written by Dr. Heywood of the Imperial College of Science and Technology. One statement which he makes, " that dynamic similarity between ball mills of different sizes is attained if the Froude number is constant," is a ready-made subject for an undergraduate dissertation, or even a debate.

On the whole, this is a practical book. The equipment described is real commercial equipment and the applications are commercial applications, from flour milling to the cleaning of blast-furnace gas. Applications in the coal industry receive a good deal of attention, from froth flotation to the transporting of coal in pipelines. There are formulae, graphs and tables which give the performance of many kinds of equipment, and the final chapter on electro-precipitation contains useful figures on the generation of dust in a variety of industrial processes, and typical performance data of electro-precipitators. Where the theory of a process is understood or accepted, it is given. Occasionally new and speculative theoretical analytical treatments are referred to, as in the assessment of the degree of mixing. The text is complete and the illustrations are profuse and clear.

In the preface to the first volume of this series, the editors wrote " Those who have been responsible for the form of the present publication were very sensible of the fact that under the stress and speed of modern industrial developments the chemical engineer is increasingly at a loss to find ready-made answers to his problems." In this third volume perhaps the ready-made answers predominate, which readers will find by no means unwelcome.

NEW BOOKS

Zahnräder. Volume II: Stirn- und Kegelräder mit schrägen Zähnen. Schraubgetriebe. By PROFESSOR DR. A. SCHIEBEL, PROFESSOR DR. R. KÖNIGER and DR.-ING. W. LINDNER. *Springer-Verlag, Reichpietschufer 20, Berlin, W.35, Germany.* (21 DM.)

The new edition of " Schiebel " is as admirable as earlier ones. In particular, the discussion of the different forms of bevel gears is particularly clear, and excellently illustrated. Attention is paid to the work of Niemann and Glaubitz on stresses, and to the " Cavex " form of worm gear. The thorough revision has made this a book which many people will want to have by them. The reviewer noted one mistake carried over from earlier editions: Equation 3.36a should be in terms of sinh *not* sin.

Collins Civil Engineers Diary, 1958, No. 3503. *Collins, 144 Cathedral-street, Glasgow, C.4.* (5*s.* 3*d.*)

Familiarity with the materials which he uses is important to a civil engineer, but it is quite impossible for him to carry all the data in his head. The publishers of this diary have attempted to compact a mass of civil engineering data into 160-odd pages. The information covers both design and field work, including a short dissertation on blasting. A few pages are also given over to frequently required mathematics.

Mechanised Work-Handling on the Machine-Tool. Machinery's Yellow Back Series No. 42. *The Machinery Publishing Company, Limited, National House, 21 West-street, Brighton, 1.* (4*s.* 6*d.*)

The developments which have taken place in recent years in machine tool design and in cutting tools, have emphasised the need for mechanical handling of the workpiece. To-day the criterion of efficiency is not necessarily the time taken to machine a given workpiece; it may be the time required to put the workpiece in the machine and remove it again after machining. The three chapters of this book provide many examples of mechanised work handling as applied to automatics and lathes; grinding machines; and fine boring, gear cutting, and transfer machines. The equipment described thus ranges from fairly simple magazine and hopper feeds to fully mechanised layouts such as are needed for use with transfer machines.

Aluminium in Packaging. *The Aluminium Development Association, 33 Grosvenor-street, London, W.1.* (10*s.* 6*d.*)

Expendable aluminium containers, packages and similar products from thin-gauge materials are discussed, for the benefit of designers and industrial users of packages, in this 44-page brochure, lavishly illustrated both in colour and half-tone. After listing the desirable properties of aluminium as a packaging material, types of container are described—built-up, shallow-formed, deep-drawn, and impact-extruded containers, foil wraps and packs, seals, capsules and labels; and the composition, properties and available forms of aluminium—foil, foil laminates, sheet and strip, slugs for impact extrusions, coatings—are detailed.

Engineering Materials, Machine Tools and Processes. By W. STEEDS. Third edition. *Longmans, Green and Company Limited, 6 and 7 Clifford-street, London, W.1.* (35*s.*)

Since the first edition in 1942 of this textbook, much additional material has been added and the treatment of some parts expanded. Included in this third edition are iso-thermal transformation diagrams, the properties of titanium, multi-spot welding machines, air gauging systems, transfer machines and tape control. Corrections have been made where necessary to bring the references to British Standard specifications up to date. The material is designed for membership examinations of the engineering institutions, for the City and Guilds Institute examinations and for National Certificate work.

Boron, Calcium, Columbium, and Zirconium in Iron and Steel. By R. A. GRANGE, F. J. SHORTSLEEVE and D. C. HILTY, W. O. BINDER, G. T. MOTOCK and C. M. OFFENHAUER. Published for *The Engineering Foundation* by *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (14 dols.); and *Chapman and Hall Limited, 37 Essex-street, London, W.C.2.* (112*s.*)

The monograph series of Alloys of Iron Research, to which the present volume belongs, is intended to provide metallurgists and engineers with concise summaries of available data, as reported in the technical literature of the world, on the effect of selected metals on carbon steel and on simple and

MECHANICS OF MACHINES

Kinematics of Machines. By ROLLAND T. HINKLE. *Longmans, Green and Company, Limited, 6 and 7, Clifford-street, London, W.1.* (45*s.*); and

Mechanisms and Dynamics of Machinery. By HAMILTON H. MABIE and FRED W. OCVIRK. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, N.Y., U.S.A.* (8·50 dols.), and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (68*s.*)

If the premium on writing text-books is too low in this country, it is far too high in the United States, and the conscientious teacher and reviewer must often hope that the flood of new books in the field of mechanics of machines will stop. Especially is this so when faced with a third printing in three years, such as Hinkle's book represents. In itself, it is quite a good book in the field which it attempts to cover; but there can be no justification in continuing to issue reprints of books which use methods of trial and error for solving awkward velocity and acceleration diagram problems, now that the method of the auxiliary point has been made readily available for the past two years or so in Holowenko's book (reviewed in the November 25, 1955, issue of ENGINEERING). Similarly, although Professor Hinkel says in his preface that he has added new material on equivalent linkages, he still does not seem to have realised the much greater generality which they give to the analysis, whether graphical or analytical, of cams.

The book by Professors Mabie and Ocvirk is in a different class. Whereas they too must be criticised on the grounds that they are apparently unaware of the elegance and usefulness of these methods, they have produced a book which should be read by every teacher or mechanics, and by a good many practising engineers. They are to be congratulated on breaking new ground in an elementary book by including two chapters on mechanisms, entitled " Introduction to Computing Mechanisms " and " Introduction to Synthesis " (of linkages). These are fields which have for too long been the preserve of German writers, and the introduction to the synthesis of linkages should stimulate many young men to take an interest in this difficult subject. The authors give Rosenauer's complex variable method for the synthesis of four-bar linkages, and also Freundenstein's three precision point method. The lucidity of their exposition is exemplary. They eschew all mention of the graphical methods general in most continental work, but it is a pity that they do not mention Roberts' theorem or discuss the general analytic properties of the four-bar chain, and its usefulness in heavy engineering.

The authors state their intentions in a long preface, and they seem to have fulfilled them. A critic who complains that he does not like a lot of their methods would be unfair, therefore, and he should leave those persons who might buy the book to judge for themselves from the copy which must surely go into every departmental library in schools of engineering.

complex alloy steels and cast irons. This new addition to the series, the fifteenth, consists of four separate short monographs on four of the alloying materials, namely, boron, calcium, columbium (plus tantalum), and zirconium. Each monograph is written by authorities in their own field. The general aim of the book is to provide a reliable foundation for further research.

Diesel Fault Tracing Maintenance and Repair. By STATON ABBEY. Second edition. *Sir Isaac Pitman and Sons Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (16*s*.)

The book was planned as a thoroughly practical manual covering the wide scope of all types of high speed Diesel engines. Since the first edition in 1950, several new types of engine have been introduced, and this, the second edition, includes references to them in the tracing of faults. In order to aid rapid and accurate work, ten systematic diagnosis charts have been prepared and incorporated in the volume.

TRADE PUBLICATIONS

Copies of any of the following trade publications are obtainable from the addresses given, though distribution is sometimes restricted.

Molybdenum Disulphide Lubricants. ALPHA MOLYKOTE CORP., 65 Harvard-avenue, Stanford, Connecticut, U.S.A. Molykote, molybdenum disulphide lubricants in paste, grease, dispersions or dry forms, giving working temperature ranges from − 100 deg. F. to + 750 deg. F. Three grades of particle size, the finest having a maximum of 7 microns. Brochure *Breaking Lubrication Barriers* gives properties, specifications and application.

Metals in Vehicles. TUBE INVESTMENTS LTD., The Adelphi, Loridon, W.C.2. Booklet *T.I. Metals in World Transport* describes the products and services given by Accles and Pollock Ltd., Metal Sections Ltd., Pel Ltd., and T.I. Aluminium Ltd., in transport vehicles of all types. Illustrations are included of sections available and methods of construction of railcars, buses, and lorries.

LaMont Boilers. LAMONT INTERNATIONAL ASSOCIATION LTD., 42 Leicester-square, London, W.C.2. The LaMont system of forced and controlled circulation and its application in the various fields of steam generation is described with drawings of typical installations in a recent booklet.

Power Quill. LORANT & CO., LTD., 98-100 Croydon-road, London, S.E.20. Precise Product Corporation's type 80 power quill, developing 1½ h.p. with variable speed range from 7,000 to 24,000 r.p.m. Capacity ½ in. collet chuck or 2½ o.d. wheels. Leaflet.

Needle Bushes. INSLEY (LONDON) LTD., 21-22 Poland-street, London, W.1. Nadella Needle Bushes with high load capacity and small space requirements. Sizes range from 6 mm. internal diameter up to 40 mm. internal diameter, corresponding external sizes being 12 mm. and 48 mm. Leaflet.

Experimental Steam Engines. W. SISSON AND CO., LTD., Sisson-road, Gloucester. Experimental steam engines for college and student use. Single or compound expansion types, high and low pressure cylinders, 6 in. and 8½ in. by 4 in. stroke. Fitted with variable expansion valve gear. Leaflet.

Oil-Free Compressor. DAWSON MCDONALD AND DAWSON LTD., Compton Works, Ashbourne, Derbyshire. Fan-cooled oil-free air compressor, diaphragm type for continuous duties up to 40 lb. per sq. in. with a delivery of 1·65 c.f.m. at that pressure. Leaflet.

Locomotive Air Filter. VOKES LTD., Henley Park, nr. Guildford, Surrey. Tests on air filters for electric and Diesel-electric railway locomotives in industrial areas. Report of trials carried out on the Manchester/Sheffield/Wath line on various types of filter.

Traffic Control Barrier. R. B. PULLIN & CO., LTD., Phoenix Works, Great West-road, Brentford, Middlesex. Power-operated traffic barriers for works entrances and similar applications. Descriptive leaflet and constructional details.

Marine Diesels. BURMEISTER AND WAIN, Copenhagen, Denmark. Two-stroke single-acting turbo-charged, crosshead main Diesel engines up to 15,000 b.h.p. Dimensions, section drawings and photographs of examples. Brochure.

Media Separation. PEGSON LTD., Coalville, Leicestershire. OCC separation vessels for heavy media separation processes. Five models up to 400 tons per hour capacity, suitable for either batch or continuous operation. Leaflet.

On the Shelf

By Frank H. Smith

I am a little disappointed in the second number of the *Journal of the Joint Panel on Nuclear Marine Propulsion*. The first paper, entitled "An Introduction to Nuclear Power," certainly is an Institute of Marine Engineers' paper. It is, in fact, the Institute's Lloyd's Register Lecture to junior members, but all the rest of the papers are reprints from the *Financial Times* Atomic-Energy Survey. They are good papers, mind you, but, speaking as a librarian, is it really necessary or desirable to add to the mass of technical literature by printing all over again something that has already appeared in this country?

Almost invariably, I give the address of any organisation I quote and when, on November 15 (page 625) I gave some information regarding the Polish concern that has an exhibition of periodicals (RUCH) without giving an address, it was queried by the editorial department. Feeling slothful I said I did not know and I did not suppose anybody would worry. The result was that the eagle-eyed British Council was telephoning me on that Friday morning almost before I had my office eyes open. For future information the address of RUCH is ul Wisza 46, Warsaw. Another inconsistency of which I was guilty was the use of I.C.B.M. without explaining that it stood for inter-continental ballistic missile, but that was put right for me. It just shows how one gets into this habit of "initialising" if one gets too familiar with a subject.

The *British Petroleum Newsletter* of November 14 announced the consolidation of their geophysical and petroleum engineering research in a new laboratory block at Sunbury-on-Thames. The *Newsletter* also tells of two new B.P. cinema films called "Test Flight 263" and "Weekend at Le Mans." The first deals with aeronautical research and the second, of course, with motor racing: the 1957 race in fact. Both of these films had their first public showings in November. Another new film, "Route des Cimes," has recently had a trade showing and I should imagine that it is spectacular. The film shows, in colour, the daily journey of a B.P. road tanker up the French Alps in winter. A lovely subject to which I am sure B.P. have done the greatest justice.

Comparative salaries of the United States are always interesting to those in this country who do not own Cadillacs or replace their refrigerators each year. The American Society for Engineering Education has extracted from the 1956 engineering salary figures, gathered by the Engineers' Joint Council, the average engineering teacher's salary (those in colleges and universities that is). This average is given as 6,634 dols. per annum, to which are added fees for consulting and other engineering work to bring the total to 8,862 dols. Young engineers serving as instructors in public institutions average 4,214 dols. and those in privately-supported schools, 4,374 dols. Heads of departments range between 9,117 dols. and 9,893 dols., and deans receive between 10,932 dols. and 11,829 dols. Of the 4,000 teachers surveyed, 80 per cent. earn income beyond their teaching salaries. These average between 2,333 dols. and 3,634 dols.

The average was calculated from replies received from more than 4,200 engineering teachers—35 per cent. of the 12,000 engineers engaged in teaching in the United States. Should any reader want further information I expect that this can be obtained from W. Leighton Collins, secretary, American Society for Engineering Education, University of Illinois, Urbana, Illinois, U.S.A.

Engineers contemplating work in connection with a seaway may like to know of the October number of the *Engineering Journal* of the Engineering Institute of Canada. Four papers therein deal with the St. Lawrence scheme, namely, "Structural-Steel Design Features and Operating Machinery for the Gate [illegible]ictures in the Locks of the St. Lawrence [illegible]way;" "St. Lawrence Power Project, 300-to[illegible]ower-house Gantry Crane;" "Montreal Area Bridge Alterations for the St. Lawrence Seaway;" and "The St. Lawrence Power-house Project."

Electronics have always struck me as being rather like the Gaelic. Either you have it or you have it not. Those people who understand the inner workings of a radio set do not *learn* the art. It is an instinct. The older members of the profession started by building, with baby hands, a small crystal set to be used with selfish earphones. Those born ten years later started with valves and went on from there. But to whichever category a person may belong, a forthcoming book will be most useful on the shelf. Heywood and Company, Limited, Drury House, Russell-street, London, W.C.2, are shortly publishing *Electronic Engineer's Reference Book*, with L. E. C. Hughes as its editor. There are over 50 contributors to this volume, which is divided into eight sections, dealing with fundamentals, radiations, electrics, valves, materials, vibrations, computers and automatics. The price will be 4 guineas.

Like all other annual issues, the annual reports of the Aeronautical Research Council get bulkier and bulkier as the output of *Reports and Memoranda* increases. Now, to make things even happier, three "independent" volumes have arrived under the title: Special Volumes I, II and III. In a preface it is explained that "owing to circumstances associated with World War II . . . a number of reports . . . have not been included in the Annual Technical Reports. . . . Rather than that these odd reports should be bound with an Annual Technical Report bearing a different date. . . it was decided that they should be bound together in Special Volumes." And here they are—over a hundred reports, in three volumes, at 22 guineas from H.M. Stationery Office.

Springer's have not wasted any time in following up their advance notices of *Archive for Rational Mechanics and Analysis* which I mentioned in this column on page 625. The first number has arrived, containing three articles in English, two in German and one in French.

The Times had a little paragraph recently on the changing face of Bond Street, quoting as an example the closing of Myers the antiquarian bookseller. In the course of an interview with Miss Myers it transpired that book collection is giving way to autographed-letter collection. Among other things, smaller flats, with no bookshelf room, are blamed for this change. An alternative to autographed letters is, of course, maps and charts which can be framed and hung on walls, made into lampshades (if you have the heart to do this), put under glass table tops, and so forth. The Parker Gallery, 2 Albemarle-street, London, W.1, specialise in this line, among others, and their catalogue V/57 is full of interest. An "Aeronautical View of London, 1831," should be interesting, and "The Proposed Wet Docks and Cut from New Gravel Lane to Blackwell, 1796," should obviously grace a wall in Victoria Street. The catalogue is well arranged in county divisions and also, alphabetically, under artists. Parkers describe themselves as the oldest-established firm of picture and print dealers and have other specialist collections concerned with such subjects as ballooning and aeronautics, sailing ships, and caricatures.

It is said (probably by a camel-driver) that straws show which way the wind blows. For years, *the* aeronautical discourse in America has been the Wright Brothers Lecture, given on the anniversary of the first powered controlled flight on December 17, 1903. This year it is to be delivered by H. Julian Allen, who is described as a "missile scientist."

Research and Development

GUIDED WEAPONS AND AIRCRAFT

Although the original conceptions of aircraft and of guided missiles were widely different, the scientific thought and skills that have gone into their aerodynamics and propulsion systems are basically similar, and in other ways their design philosophies and techniques are converging. Such are the thoughts expressed by Mr. J. E. Serby, C.B.E., director of guided weapon development at the Ministry of Supply, in the inaugural lecture on "Guided Weapons and Aircraft—Some Differences in Design and Development," given before the newly-formed Guided Flight Section of the Royal Aeronautical Society in London recently. We give below a digest of Mr. Serby's paper.

SHAPE AND WEIGHT

In aerodynamics, the guided weapon has the advantage of avoiding all the difficulties of take-off and landing, and most of the difficulties of the "sound barrier" through which it is boosted so quickly that no serious transonic problems are met. The apparent marked difference in configuration between the guided weapon and the aircraft arises mainly because the missile can operate at a much higher wing loading—say 2½ to 3 times that of a modern fighter, for a crusing speed of Mach 2. Most British and American weapons have straight wings, which are more efficient around Mach 2, unless the sweepback is 60 deg. or more. However, provided that control problems can be solved, the highly-swept delta configuration may in future be seen more often on account of its structural and weight saving advantages.

Missile wings may be moving or fixed; lift and manoeuvre acceleration can be achieved more quickly with moving wings, high rate of roll can be achieved, and body incidence is kept lower—an advantage in the case of air-breathing motors, and also in the reduction of radome aberration. Their disadvantage lies in the greater weight of their larger surface area and wing actuating mechanism.

Missile designers also have the choice of cruciform wings or monoplane configuration. With the latter, changes of direction are made by rolling and then pitching ("twist and steer"), whereas with cruciform wings, appropriate amounts of pitch and yaw control are applied simultaneously. The wing weight is lower for the monoplane, but on fixed wings much larger control surfaces will be required for adequate roll response. The monoplane layout is also more suitable for mounting external motors.

In most guided weapons, the sustaining power plant is completely integrated with the rest of the missile—an important factor in the aerodynamic efficiency. This point is illustrated in Fig. 1, which shows the de Havilland Firestreak weapon. The case of the ramjet-propelled missile (Fig. 2) is naturally different since properly-designed and located air intakes have to be provided.

In the ballistic missile, where there is considerable excess thrust, drag is of small importance, but in the fairly long-range surface-to-air weapon, where a considerable part of the flight is at cruising speed through the atmosphere, a reasonable lift/drag ratio must be achieved, and the missile design desiderata approach that of the aeroplane.

As regards weight, savings in the weight of structure, propulsive plant and tanks are particularly important for the ballistic missile. The latter can expect to achieve a ratio of initial all-up weight to residual weight, when all fuel is consumed, of about 20, whereas the long-range aeroplane is doing well if it achieves a value of about 2. The aeroplane expends its fuel energy in steadily overcoming its own drag, whereas the ballistic missile uses it to impart kinetic energy to its payload.

In the complete development cycle of missile and aeroplane there are fundamental differences. The selection and location of guidance equipment and warhead is all-important in the early layout stage of the missile. In wind tunnel testing there is much in common, with more high-incidence tests and investigation of cross-coupling effects for the missile. In the ballistic missile, the problems of control where no atmosphere is available and of re-entry into the atmosphere without catastrophic burnout demand considerable research.

At the prototype stage, the aeroplane must be a complete flying machine, whereas missile problems can be tackled by separate test rounds to evaluate successively propulsion and drag parameters, control functioning, guidance system, and finally, closing the loop from guidance to controls. This entails flying some 200 missiles in the course of development as against two to six prototype aeroplanes—an expensive programme which demands not only that every part of the missile works but also that the required data is properly transmitted back to the ground.

ONE COMPONENT FAILURE—MISSILE FAILURE

It is by developing each individual component to the required reliability—which increases as the complexity of the missile grows—that overall missile reliability can be achieved, rather than by firing ever-increasing numbers of missiles. This overall reliability, on which the success of the missile depends, includes the ground radars, control posts and launchers, and also must take account of the hazards of transport, storage and handling in service environments.

In contrast the civil aeroplane, although highly complex, can survive the failure of quite a few of its components, one reason being that it has standby equipment which can be brought into use if the primary equipment fails. This demands the presence of a human pilot who can exercise discretion. The guided missile has no standby equipment; and the military aircraft is coming more into line with the guided weapon—with automatic target recognition, target seeking, bomb-aiming and even stability relying on electronics—where, in general, failure of one component will prevent a successful mission.

SALVAGING TEST MISSILES

To supplement telemetry and to make possible repeated firings of test missiles, recovery techniques have been developed. One way of slowing down the vehicle before impact is to break off the head by an explosive charge at the end of the useful trajectory, the increased drag reducing the impact velocity to about 250 ft. per sec. More sophisticated systems have been developed both by the Bristol Aeroplane Company, Limited, and by the English Electric Company, Limited, in which multi-stage drag-producing devices, either airbrakes or parachutes, slow the vehicle down to impact at about 60 to 70 ft. per sec. Fig. 3 shows a Bristol test vehicle after landing on its spike, which assists in the final deceleration. For recovery from a sea range, the Royal Aircraft Establishment have successfully developed a buoyancy system—but the corrosion problems are severe. More potentially profitable is a system for recovering the missile in flight, on which the Weapons Research Establishment at Woomera is working and has already been successful with small vehicles.

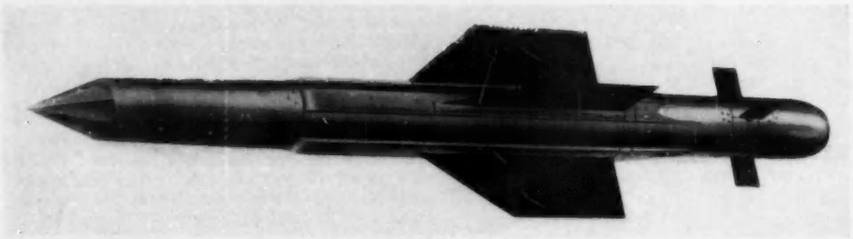


Fig. 1 The de Havilland Firestreak weapon—a completely integrated rocket propulsion system.

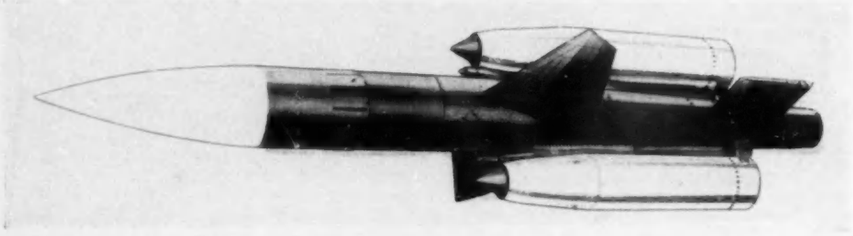


Fig. 2 In contrast, where ram-jets form the main propulsion units, they must be placed so as to provide efficient air intakes.

Fig. 3 Recovery of a Bristol test vehicle.

CURRENT RATING TESTS ON DOUBLE-ANGLE SECTION COPPER CONDUCTORS

By T. L. Richards, B.SC.(ENG.), A.M.I.E.E.*

The design of bare conductors in general, and heavy current connections in particular, was dealt with in detail in an earlier article in this journal.[1] The article reviewed all the factors to be taken into account, including skin and proximity effects and equi-inductance lines. Laminated bars were shown to be uneconomic for currents in excess of about 3,000 amperes and it was concluded that structural sections, and in particular double-angle sections, would prove to be the best long-term proposition. The calculations which accompanied the article were based upon current ratings established for angle and channel sections, as a result of tests carried out on behalf of the Anaconda Wire and Cable Company[2] and reproduced in the publication *Copper for Busbars*.[3]

The American tests determined the current rating on a basis of a 30 deg. C. permissible temperature rise on a 40 deg. C. ambient, but since British practice† now recognises a permissible rise of 50 deg. C. on a 30 deg. C. ambient, recent editions of the above publication have contained estimated ratings on the latter basis.

ESTIMATED RATINGS TOO HIGH

As a result of the interest shown by the C.E.A. and various manufacturers in the use of structural sections for alternator-transformer connections, the Copper Development Association commissioned tests by the National Physical Laboratory in order to confirm the current ratings estimated from the American test figures. Twelve-foot lengths of angle section conductor in high conductivity copper were obtained in three different sizes of section and the following tests were planned:

(1) single-phase tests on double-angle conductors (3 in. by 3 in. by $\frac{1}{4}$ in. sections) at 15 in., 18 in. and 30 in. centres;

(2) single-phase tests on double-angle conductors ($3\frac{1}{2}$ in. by $3\frac{1}{2}$ in. by $\frac{1}{4}$ in. sections) at 15 in., 18 in. and 30 in. centres;

(3) three-phase tests on double-angle conductors ($2\frac{1}{4}$ in. by $2\frac{1}{4}$ in. by $\frac{5}{16}$ in. sections) at 15 in. phase separation.

The bars were mounted horizontally about 20 in. from the floor in a large room which enabled a constant ambient temperature to be maintained. Still-air conditions were achieved by the use of screens, and the temperatures of the bars were determined by means of thermocouples.

The first series of tests produced results which gave disappointingly low current ratings, as will be seen from the fact that the 3 in. by 3 in. by $\frac{1}{4}$ in. angles had a rating of less than 3,800 amperes although the estimated figure had been 4,900 amperes.

The test conditions were therefore examined in the light of the test results and it was decided that several factors might be contributing to the low current ratings obtained.

SPACING OUT AND BLACKENING CONDUCTORS

In the first place the $\frac{1}{4}$ in. spacing between the two angle bars comprising each conductor seemed, upon consideration, to be rather small, and it was thought that this spacing could be profitably increased in order to improve the ventilation. It was also noted that there were considerable differences between the temperature rise figures for the two component bars of each conductor (see Tables 1 and 2) and since this was apparently due to the failure of the double-angle section to coincide with the equi-inductance lines, it was decided to carry out additional single-phase and three-phase tests.

The single-phase tests were restricted to the 3 in. by 3 in. by $\frac{1}{4}$ in. bars, and included a test on the conductors as used in the initial tests but with a 96 in. centre distance between the "go" and "return" conductors, this being the greatest separation obtainable with the test equipment at the N.P.L. The conductors were then set at 15 in. centres and the space between component bars increased to $\frac{3}{4}$ in. In addition, the same conductors were tested at 15 in. vertical spacing. Finally, a test was carried out with blackened conductors at 15 in. horizontal spacing.

The three-phase tests were also repeated, first with the spacing between component bars increased to $\frac{3}{4}$ in. and finally with the conductors arranged in triangular formation. The complete set of test results is given in Tables I and II at the foot of the page.

AMERICAN TESTS DIFFER

It should first be mentioned that in establishing a current rating from the test results it is necessary to decide which of the following should be taken as representing the "temperature rise":

(1) the maximum temperature rise noted among the component angle bars of the conductors under test;

(2) the mean of the temperature rise figures for the hotter of the two component angle bars of each of the conductors under test;

(3) the mean of the temperature rise figures for all the component angle bars of the conductors under test.

Since joint temperature is the critical factor, it can be argued that the substantial components used for joining double-angle conductors would equalise the temperature at the joints, and that therefore the current rating should be based on the mean of the temperature rise figures for all the angle bars of the conductors under test (condition 3). Current ratings on bases 2 and 3 are, however, given in Tables I and II, and it will be noted that although the more optimistic method gives an improvement in rating, the figures so obtained still fall short of the calculated rating.

Of the measures adopted in an attempt to improve upon the current-carrying capacity indicated by the first series of tests, blackening of the bars was easily the most effective, since it resulted in an increase in rating of almost 20 per cent. The spacing between component angle bars was also shown to be an important factor. Increasing the spacing between conductors was the least effective of the modifications tried, and it will be noticed in particular that even 8 ft. spacing between the go and return conductors was insufficient to equalise completely the temperatures of the two component angles of each conductor.

In attempting to account for the discrepancies between the results of the American and British tests, it was established that the former were in fact for conductors with remote returns. However, since the N.P.L. test on conductors with 8 ft. spacing failed to equal the rating based on

TABLE I.—*Single-Phase Tests on Double-Angle Conductors*

Conductor	Disposition	Spacing between centres (in.)	Space between component bars (in.)	Current (amperes)	Temperature rise in deg. C.				50 deg. C. rating—based on mean highest temperature (amperes)	50 deg. C. rating—based on overall mean temperature (amperes)	Estimated current rating (amperes)
					"Go" conductor		"Return" conductor				
					Bar A	Bar B	Bar C	Bar D			
$3\frac{1}{2}$ in. × $3\frac{1}{2}$ in. × $\frac{1}{4}$ in.	A B C D <> <>	15	$\frac{1}{4}$	3,000	21·0	32·0	33·5	22·5	3,880	4,140	5,500
				4,000	34·0	51·5	54·0	36·5			
		18	$\frac{1}{4}$	4,000	36·5	51·5	53·5	39·0	3,900	4,160	
		30	$\frac{1}{4}$	4,000	39·5	49·5	50·0	41·0	4,000	4,260	
3 in. × 3 in. × $\frac{1}{4}$ in.	A B C D <> <>	15	$\frac{1}{4}$	2,750	26·0	36·0	34·5	25·0	3,410	3,700	4,900
				3,500	38·0	53·5	51·0	37·0			
		18	$\frac{1}{4}$	3,500	39·0	52·0	49·5	37·5	3,460	3,710	
		30	$\frac{1}{4}$	3,500	42·0	49·0	47·0	39·5	3,540	3,770	
		96	$\frac{1}{4}$	3,400	35·5	38·5	—	—	3,850	3,960	
		15	$\frac{3}{4}$	3,500	31·5	48·5	47·5	33·5	3,610	3,970	
		15 (blackened bars)	$\frac{3}{4}$	4,250	33·5	48·0	48·0	32·5	4,340	4,750	
	A <> B C <> D	15	$\frac{1}{4}$	3,500	44·0	45·0	40·0	39·5	3,740	3,830	

TABLE II.—*Three-Phase Tests on Double-Angle Conductors*

Conductor	Disposition	Spacing between centres (in.)	Space between component bars (in.)	Current (amperes)	Temperature rise in deg. C.						50 deg. C. rating—based on mean highest temperature (amperes)	50 deg. C. rating—based on overall mean temperature (amperes)	Estimated current rating (amperes)
					Left-hand conductor		Centre conductor		Right-hand conductor				
					Bar A	Bar B	Bar C	Bar D	Bar E	Bar F			
$2\frac{1}{4}$ in. × $2\frac{1}{4}$ in. × $\frac{5}{16}$ in.	A B C D E F <> <> <>	15	$\frac{1}{4}$	1,700	21·0	26·5	22·0	27·0	26·5	24·0	2,430	2,550	3,300
				2,300	35·5	44·0	37·0	45·5	44·5	39·5			
			$\frac{3}{4}$	1,700	19·5	26·0	20·0	26·0	24·5	21·0	2,470	2,620	
				2,300	33·5	44·0	33·5	44·5	41·5	36·0			
	C D <> A B E F <> <>	30	$\frac{1}{4}$	1,700	21·5	23·0	21·5	22·5	23·5	21·0	2,620	2,710	
				2,300	35·0	39·0	35·5	38·0	40·5	35·5			

* Electrical Engineer to the Copper Development Association.

† B. S. 159 (1955).

Continuing
Research and Development

the corresponding American test figure, some other explanation must be found. The one factor on which no check can be made is the comparative efficiency of the methods used to screen the conductors and so achieve still air conditions, and it can only be assumed that it is this important factor which accounts for the major part of the appreciable differences existing between the two sets of results.

CONCLUSIONS

While the tests did not in fact confirm the anticipated current ratings of the three sizes of angle section, a number of useful results were obtained. In the first place, it was shown that the basic relationship $I = k\theta^{0.61}$, established for circular and rectangular sections,[3] is at least approximately correct for angle sections. Secondly, it was confirmed that blackening of the bars is as effective with angle sections as it is with rectangular conductors,[4] an increase in rating approaching 20 per cent. being achieved in both cases. Finally, an indication was obtained of the importance of spacing both between component angle bars and between conductors.

The results obtained were for conductors rather smaller than those required for machines of 60 MW output and greater, but they are considered to be of value as they indicate that the ratings hitherto suggested for angle sections should be used with some discretion. Even more important, they suggest that in order to determine the most economical section for each standard size of C.E.A. alternator, larger bars, possibly including channel sections, should now be tested and that the tests should if possible include the investigation of the effect of various types of enclosure.

REFERENCES

[1] "Bare Conductors for Generator Transformer Connections," by J. B. Laurie, ENGINEERING, vol. 178, page 143 (1954).
[2] *Anaconda Bus Conductors*, Publication C25, The American Brass Co.
[3] *Copper for Busbars*, p. 30, The Copper Development Association (1954).
[4] S. W. Melsom and H. C. Booth, *Journal of the Institution of Electrical Engineers*, vol. 62, page 909 (1924).

TWISTOR—A NEW COMPUTER MEMORY

Storage of information plays an important part in computers. The "memories" that perform this function have to meet a variety of requirements. Two in particular—rapid accessibility to the information and large capacity—play an important part in removing the solution of certain complex mathematical problems from the realms of impossibility. A further requirement is that the memory should be economic to manufacture.

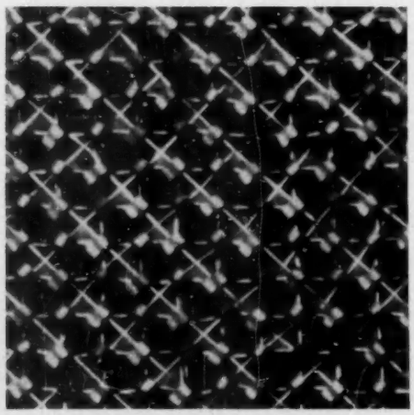


Fig. 1 Ferrite cores are often used in computers to store information. An alternative store, using magnetic wires, might offer the same facilities with a much simpler form of construction.

Ferrite cores give a convenient storage system. They are used in the Mercury computer manufactured by Ferranti Limited, Hollinwood, Lancashire. Fig. 1 shows an assembly of ferrite cores in part of the Mercury high-speed store. The cores are toroidal and are allowed to exist in only two magnetic states—fully magnetised in one direction or fully magnetised in the reverse direction. In the coding system used, one magnetic state corresponds to the digit "1," the other corresponds to "0." A matrix of cores can thus be connected up to represent a wide variety of numbers in the binary system, for example, 1001101—the binary equivalent of 77.

Three wires thread the cores. The arrangement can be seen in the illustration. Wires arranged vertically and horizontally carry the currents that put the cores into either of the desired states. The set of wires forms a grid and any two wires will select any one core. Besides "writing" the required information into the appropriate cores, the column and line wires are used to initiate the "reading" process. When this occurs, the output—describing the contents of a particular part of the store—appears on the "read" wire, which passes axially through the cores. In Mercury the cores are arranged in square arrays containing 1,024 cores (32×32). By using ten arrays a basic storage capacity for 1,024 "words" of 10 digits is obtained.

A magnetic memory of similar form but simpler construction is being studied at Bell Telephone Laboratories, New York. The device has been named the "twistor." It is visualised that the device will eventually be made merely by interleaving horizontal copper wires and vertical magnetic wires. No separate cores will be used. Such a construction would be simpler to fabricate and might well be cheaper to manufacture than existing systems.

The magnetic wire might consist of a conductor plated with a magnetic material. Current pulses through any two wires mutually at right angles will write in information at their point of intersection, the information being stored on a small region of the magnetic wire. The reading process will be initiated by a pulse on the copper wire. When this occurs an output appears at the end of the magnetic wire.

The new device gets its name "twistor" from a characteristic of wire made of magnetic material. Torsion applied to such a wire shifts the preferred direction of magnetisation from a longitudinal to a helical path. It is then necessary to insert information into the wire in the form of polarised helical magnetisation. And although this type of magnetisation is perhaps a little unfamiliar it is relatively easy to achieve. The current pulses through two crossing wires

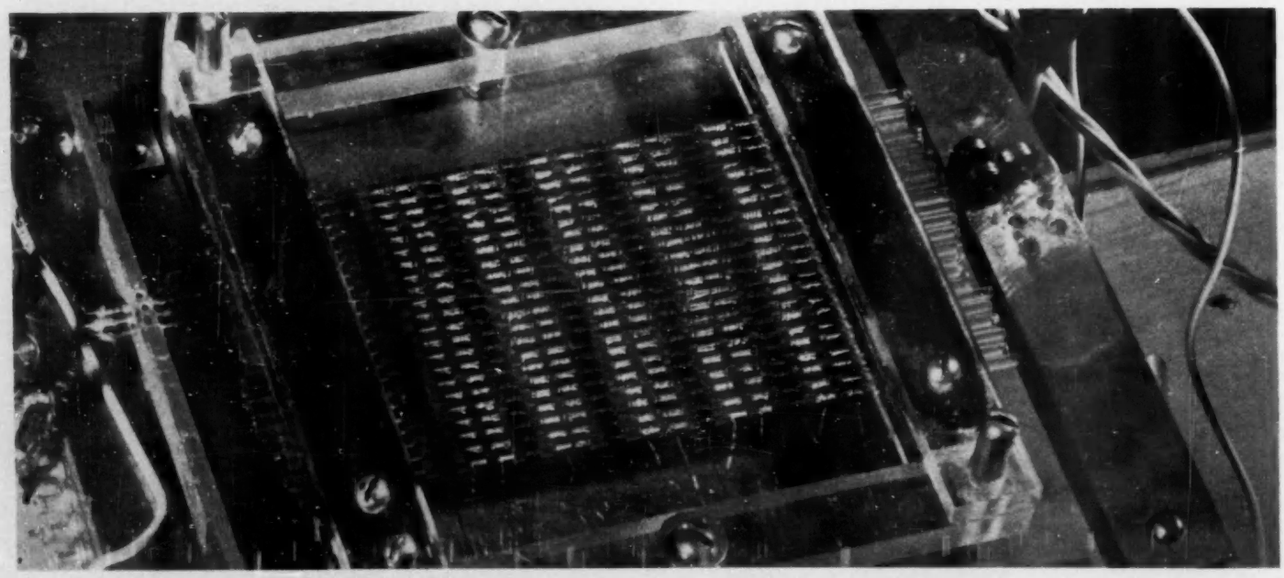


Fig. 2 An experimental array is being used to test various magnetic wires. Information is stored by helical magnetisation, achieved by compounding longitudinal and circular magnetic fields. Solenoids provide the longitudinal field in the device shown, the self-magnetism of the current-carrying magnetic wire giving the circular field. Later the solenoids will be replaced by copper wires at right angles to the magnetic wires.

give rise to circular magnetic fields around each wire. The interaction of the fields produces a helical field around the magnetic wire; for it experiences the resultant of its own circular field and the component of the copper-wire field that is directed along the length of the magnetic wire.

Application of torsion to the magnetic wire in a final device may be unnecessary. It may be possible to " freeze " the preferred direction of magnetisation into the wire during processing.

Fig. 2 shows an experimental array that has been set up. The transverse copper wires have been omitted and the longitudinal field in the magnetic wires is provided instead by small solenoids wound round glass tubes. Such an arrangement facilitates the testing of various types of magnetic wire. Investigations are now under way to determine the optimum size and composition for the magnetic wires. Diameters as small as 0·001 in. appear to be feasible.

At least ten " bits " per inch may be stored on such a wire without adverse interaction. Speed of operation and output of the device are comparable to ferrite memory systems. Bell Laboratories also say that present indications are that the drive circuits for the twistor array can be readily transistorised. It appears therefore that the device will retain all the advantages of ferrite core systems, and will be much simpler to fabricate.

Metals and Materials

UNCERTAIN OUTLOOK FOR COPPER

There is a feeling of uneasiness about the future of copper. The leading producers have forecast that the price had reached its lowest level some weeks ago but no appreciable recovery has yet taken place. Sir Ronald Prain then described the immediate outlook as confused, linking the fall in price to the general weakness in commodities. In his speech to the shareholders of Rhodesian Selection Trust last October he said " Recent weeks have seen the price reach a point where some resistance appears to have been encountered " but that it was " too early to say what may be the outlook for next year." In his speech to the shareholders of Rhodesian Anglo American at about the same time, the late Sir Ernest Oppenheimer said that he considered the price had " fallen lower than the over-supply position of the metal justifies."

A meeting of the International Non-Ferrous Metals Council earlier this month, attended by representatives of a number of producers, including those from Chile, led to expectations of a planned reduction in output which sent the price of three months copper up nearly £5 to £192 a ton. Nothing happened, however, and the outlook remains uncertain. There have been rumours of a planned reduction in output by the Chilean producers, based on the belief that Chile would prefer to rely on a greater revenue resulting from a general cut of production of, say 10 per cent., with the prospects of higher prices, to a continuation of the present revenue received from full-scale production. Both R.S.T. and Rho-Anglo have announced that output during the current year would be reduced by 10 per cent. though in the case of the latter this is due to difficulties experienced at their Bancroft mines.

Unless the demand in the United States recovers within the next few weeks cut-backs in the output of all major producers are inevitable. But there is little doubt that the fall in price of more than £100 a ton has had a salutory effect on the industry. In particular, it has acted as a very real incentive to lower costs of production. The danger, from the users' point of view, is that price will rise once again and that producers will ensure that it is maintained at " a reasonable level."

TIN QUOTAS

At their recent meeting in London the International Tin Council decided on a large cut in exports of tin. This is equivalent to a drop of 28½ per cent. in the annual rate of production in the six producing countries which are members of the agreement. The scheme which has been worked out should ensure that the quotas are effective in reducing the present surplus.

Stabilisation is being sought by the use of a buffer stock in association with the imposition of quotas. Only 27,000 tons will be allowed to be exported from these countries (they account for 90 per cent. of world output) and the quotas will cease at March 13 next unless they are renewed. To prevent too sharp a rise in prices the buffer stock held jointly by producers (who have recently contributed £3·6 million to it) will be used. The manager of the stock, who is not normally allowed to sell tin unless the spot price is £839 or more, is now empowered to sell when the market is £781 a ton or higher and forced to sell when it reaches £880.

Malaya, which is the biggest producer in the world (37·5 per cent. of the total compared with 20·4 per cent. each by Bolivia and Indonesia) has for some time legalised the cut-back of domestic production. Kuala Lumpur miners expect the cuts to cause some unemployment but not so much as that caused if more mines had to be closed owing to further deterioration in prices. The restrictions agreed upon by the tin producers have the merit of preserving some order and stability in the market, without which there would be disputes likely to damage the efficiency of the mines and ultimately the interests of users.

FIRE HAZARD OF FLAME CUTTING AND WELDING

Every year fire brigades in this country are called to some 700 fires caused by flame cutting and welding and even this large number does not take into account the many smaller fires dealt with without the help of official fire-fighting units. Fires occurring during cutting and welding may be caused by faulty or badly-maintained equipment, or by the failure to protect nearby combustible material from the heat generated during the process or from sparks or hot electrode " stub ends."

A new *Fire Protection Bulletin*, issued by the Fire Officers' Committee Fire Protection Association, 15 Queen-street, London, E.C.4, describes the precautions which should be taken with both oxy-acetylene and electric equipment. It is pointed out that undoubtedly the chief danger arises where welding or cutting is employed for constructional or repair purposes in conditions which may be ill-adapted for this purpose rather than in a department allocated to such work where the structural features can be appropriate and combustible matter rigidly excluded.

The Bulletin deals with safe methods of working and with the use and maintenance of equipment. A section summarising the precautions necessary with drums and tanks which have contained inflammable liquids is also included.

Copies of the Bulletin, which is entitled *The Fire Hazard of Cutting and Welding*, are being circulated to all members and associate members of the Fire Protection Association but they can be obtained free of charge on application to the Association at the address given above.

BENEFICIAL ADDITIVES FOR FUEL OILS

The aim of most combustion additives to liquid fuels is primarily to reduce plant corrosion and fouling, but the resulting reduction of air pollution by sulphur trioxide and soot is also of importance. This statement was made in the course of a paper by Dr. B. J. Zaczek and Dr. R. Grindley, on " Fuel Additives in the Fight Against Corrosion," presented at the Corrosion Convention, sponsored by the monthly journal, *Corrosion Technology*, and held in London recently.

These authors concluded that the mechanism of the action of fuel additives is still obscure. Substances used for this purpose are hydrocarbon solvents, such as petroleum distillates, pyridine and the higher-boiling tar bases; metal soaps such as the stearates and naphthenates of aluminium, zinc, copper and magnesium; organic nitrogenous bases and their salts; inorganic bases and salts such as dolomite, zinc oxide, magnesium carbonate, china clay and talcum; metals in powder form such as zinc dust; and finely divided absorbents such as amorphous carbon. Of the inorganic additives, the bases and salts may function by the absorption of sulphur trioxide, or, in the case of the bases, by neutralisation. Zinc dust may function by forming zinc oxide which acts as an absorbent, and carbon and carbon smokes may act as absorbents or may function as reducing agents of sulphur trioxide.

A new combustion additive in powder form—Amber SSR 113—developed by the Amber Chemical Company, Limited, 11A Albemarle-street, London, W.1, of which firm Dr. Zaczek is technical consultant and Dr. Grindley, chief chemist, is being tested in the boilers of the new oil-fired power station at Marchwood, Southampton. The trials are being conducted by the Southern Division of the Central Electricity Authority and their purpose is to evaluate a variety of additives in the treatment of a residual fuel oil having a sulphur content of from 3 to 4 per cent.

The additive is in the form of a fine grey powder composed of alkaline earth and certain other metals. In use it is injected directly into the combustion zone by means of apparatus employing compressed air, and it is claimed that the treatment costs average from 1*s.* 3*d.* to 1*s.* 9*d.* per ton of fuel consumed.

The main results achieved at Marchwood through the use of the Amber SSR 113 process are stated to include a reduction in the incidence of sulphur corrosion by 50 per cent., as shown by corrosive probe tests; a reduction in the deposits in the air heaters enabling the boiler using the process to continue in action for periods in excess of twice as long as boilers using untreated fuels; and a reduction of approximately 65 per cent. in the sulphur trioxide content of the flue gases. A further matter of interest is that a very significant change has taken place in the nature of the deposits in the grit arresters. With the Amber Company's additive in use the deposits are of a light, dry friable nature, allowing the grit arresters to operate efficiently. It is pointed out that, on the other hand, untreated fuel produces deposits of a wet, sticky nature having high acidity and resulting in the rapid blocking of the grit arresters.

It would appear, therefore, that the adoption of the Amber SSR 113 process should be of interest to large-scale consumers of residual fuel oil, enabling them to effect savings in boiler-operation and maintenance costs, and assisting them to comply with the obligations of the Clean Air Act of 1956.

Atomic Review

Fast and Various

ONE of the most significant events of the coming year will be the start-up of the Dounreay fast-fission reactor. The reactor, which was fully described in ENGINEERING last May and June (vol. 183, pages 610, 665 and 724), is due to become critical in April or shortly afterwards. During December fertile material for the breeding blanket has been loaded into the reactor and graphite reflector placed in position. Construction and installation are well advanced, and some recent views of the project are shown in Figs. 1 and 2. The main call for fast-fission reactors arises from their breeding characteristics: they represent the only known system capable of converting fertile uranium 238 to fissile plutonium with a breeding ratio greater than unity (that is, they produce more fissile material than they consume), although a breeding gain is also possible with thermal reactors using the thorium-uranium 233 cycle. Fast reactors may also prove to be the most convenient method of burning plutonium.

Reactor systems that are likely to arouse increasing interest in the New Year are those based on the use of ceramic fuels, either as discrete ceramic or cermet elements or dispersed throughout the graphite moderator. Some comments on these systems, which may be used in conjunction with closed-cycle gas turbines, are also given. A prototype reactor using ceramic elements is to be built on the Winfrith site, and North American Aviation and General Dynamics Corporation are known to be working on similar systems in the United States. Reference is also made to the Shippingport pressurised-water reactor, which has recently become critical. Some notes on fast and various other reactor systems appear below.

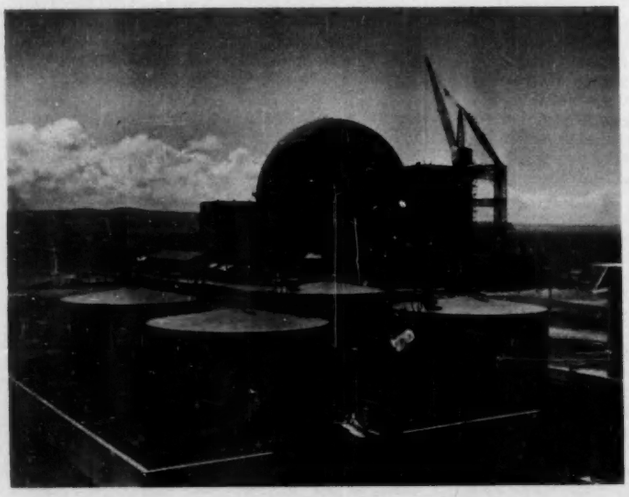


Fig. 1 View of the Dounreay site, showing the sphere of the fast-fission reactor, in which the breeding blanket and graphite reflector have recently been installed. In the foreground are Diesel fuel tanks for auxiliary plant.

Dounreay Fast Reactor

Construction and installation of the Dounreay Fast Reactor are now approaching completion. Designed to produce 60 MW of heat, it is being fuelled initially with a uranium 235-uranium 238 mixture of relatively high enrichment, and ultimately, it is planned, with plutonium. It is stated that the plutonium loading will probably not be made before 1963. The reactor coolant is liquid sodium, but early operation will be with sodium-potassium alloy (NaK) to avoid freezing problems. Fig. 1 shows the reactor sphere with Diesel fuel storage tanks in the foreground (auxiliary power is provided by Diesel installations), and Fig. 2 is a view of the reactor vault. Fig. 3 is a simplified diagram of the reactor control system taken from a paper by Dr. J. V. Dunworth; the actual arrangement of the control elements was shown in a drawing published in our articles referred to in the introduction.

Dr. Walter H. Zinn, of the United States Atomic Energy Commission, has commented on the reactor design as follows. (The remarks are taken from a report, "Power Reactor Technology—A Summary of Recent Developments," prepared by Dr. Zinn and his associates of the General Nuclear Engineering Corporation, Dunedin, Florida, for the United States Atomic Energy Commission.) Fuel elements are annular in cross-section. The reasons for this design have not been discussed, but it is known that the British have given a great deal of attention to the problem of fuel element bowing. Niobium jackets are used for the core fuel elements. Previous practice of jacketing metallic uranium fuel elements with steel allows the possibility of formation of a eutectic alloy of uranium and iron if the uranium ever approaches the melting point. The Dounreay reactor uses steel jackets for the blanket elements only.

Steam is generated at the relatively low pressure of 150 lb. per sq. in. and is superheated to 270 deg. C. (518 deg. F.). It is stated that these steam conditions may be improved later to 200 lb. per sq. in. and 328 deg. C. (622 deg. F.). The primary coolant inlet temperature is approximately 200 deg. C. (392 deg. F.) and the outlet approximately 350 deg. C. (662 deg. F.). The American reactor EBR-I generated steam at 405 lb. per sq. in. and 276 deg. C. (529 deg. F.). Corresponding values for EBR-I were 228 deg. C. (442 deg. F.) and 316 deg. C. (600 deg. F.). (It should be emphasised that EBR-I was a much smaller reactor with a heat output of 1·4 MW.)

U.S. Fast Reactor Programme

Mr. W. Kenneth Davis, director, Division of Reactor Development, U.S.A.E.C., reported at the recent fast-reactor conference (Chicago, November 20 and 21) on the fast reactor programme. The Power Reactor Development Company (PRDC) has made progress on the design and construction of the Enrico Fermi Nuclear Power Plant. The Los Alamos Scientific Laboratory (LASL) has continued its development of molten plutonium reactors and has initiated important work on fast reactor safety. A portion of the Nevada Test Site has been set aside for fast reactor transient studies. More recently, the Mound Laboratory, under the Monsanto Chemical Company, has been brought into the fast-reactor programme. The melt-down of the EBR-I Mark II core has yielded some important lessons, both in the design of fast-reactor cores and in the method of performing fast-reactor experiments. The Argonne National Laboratory has built the Mark III with forced cooling designed to avoid thermal warping of the fuel elements, which it is believed will remove one of the major causes of the instabilities noted in the Mark II core. Dry criticality was reached the last week in October and the core removed for coolant circulation tests. The core was then reloaded for wet criticality tests and low-power operation was begun two weeks ago. The EBR-II is now in the final design stage.

Present plans call for the reactor to be in operation in early 1960. Mr. Davis also visited the United Kingdom's Dounreay reactor in September and was impressed with the progress that has been made since his visit a year ago. This reactor, which differs in some respects from our EBR-II, will, Mr. Davis said, be of great value and importance to the United States

Fig. 2 Reactor vault of the Dounreay fast reactor. The 12 circular covers surrounding the reactor space seal the tubes containing the reactor control mechanisms. The reactor pot occupies the centre cavity.

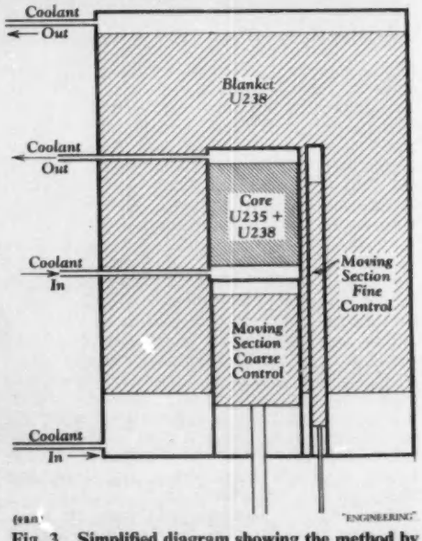


Fig. 3 Simplified diagram showing the method by which the Dounreay fast reactor is controlled.

programme when it goes into operation early next year. The U.S.A.E.C. is devoting 13·6 million dols. to fast-reactor studies in the financial year 1958.

Fused Salt Fast Breeder

An externally cooled, fused-salt, fast-breeder reactor producing 700 MW of heat has been designed utilising plutonium as the fuel in a mixture of the chlorides of sodium, magnesium, uranium and plutonium. Depleted uranium is used as the fertile material in a blanket of uranium oxide (UO_2) in sodium. Nuclear calculations have been performed with the aid of the UNIVAC computer for multi-group, multi-region problems to obtain an optimum nuclear design of the system with the chosen fused salt. Steam temperature and pressure conditions at the turbine throttle were maintained such that the incorporation of a conventional turbine-generator set into the system design is possible. An economic analysis of the system, including estimated chemical processing costs, has also been prepared. The analysis indicates that the fused-salt system of this study has an excellent potential for providing economic nuclear power. It was not learned until the completion of the study of the severe (n, p) cross-section of the chlorine35 in the range of energies of interest. This effect was amplified by the high chlorine/plutonium ratio present. It was determined, however, that chlorine37 had a high enough threshold for the (n, p) reaction so that it could be tolerated in this reactor. The requirement for chlorine37 necessitates an isotope separation which is estimated to add 0·5 mills per kWh to the cost of power. The power cost would then be 7·0 mills per kWh instead of the 6·5 mills per kWh reported. (J. J. Bulmer, E. H. Gift, R. J. Holl, A. M. Jacobs, S. Jaye and E. Koffman: Oak Ridge School of Reactor Technology, Tennessee). This note has been adapted from *Nuclear Science Abstracts*.

Metallic Slurry Systems

Factors influencing the selection of metallic slurry systems for possible use as reactor fuel elements are considered in an Atomic Energy Research Establishment Metallurgy Division report. The systems UPb_3 in lead, U_3Bi_5 in bismuth, and uranium in sodium, have been examined in some detail. An account is given of their preparation and properties, particularly in respect of particle growth. Some lines of further development are discussed. (G. W. Greenwood and B. Sharpe: AERE M/R2259.)

U—Pu—Heavy-Water Reactor

The study of the kinetic behaviour of a heavy-water moderated nuclear reactor fuelled with a combination of uranium 235 and plutonium 239 has been made. From this system there are formed primary neutrons from fissions and from the instantaneous D(γ, n)H reaction in the moderator. The threshold for the D(γ, n)H is at approximately 2·2 MeV, so a considerable fraction of the neutrons in the system have their origin in the moderator. The reactor transients are not primarily concerned with the prompt neutrons but with the neutrons that make their appearance at a time later than that of the original fission. The delayed neutrons are from the neutron-rich fission fragments and from delayed gamma emission from the fragments. (D. T. Houser and M. V. Davis: General Electric Co., Hanford Atomic Products, Washington.)

Ceramic-Fuel Reactors

In the survey prepared by Dr. Zinn, referred to above, comments are also made on reactors employing ceramic fuels. Certain high-temperature gas-cooled reactors have been proposed, which in reasonably large sizes have promised good neutron economy and therefore the possibility of low fuel burn-up cost. These proposals depend on the use of non-metallic fuel elements. No fuel element of this kind is known to have demonstrated the ability to contain fission products at high temperature. If a high-temperature ceramic or ceramic-like (cermet) fuel element of low absorption cross section, capable of containing fission products is developed, the prospects for a closed-cycle gas-turbine system will be extremely bright.

Shippingport PWR

As announced in Atomic Review on December 6, the first full-scale American power reactor, that at Shippingport, Pennsylvania, went critical on December 2. That date marks the fifteenth anniversary of the achievement—on December 2, 1942—of self-sustaining nuclear fission in the world's first reactor at Chicago, designed and built under the supervision of the late Enrico Fermi. The Westinghouse Electric Corporation designed and constructed the nuclear portions of the plant, which is to be devoted exclusively to civilian purposes, under contract to the U.S. Atomic Energy Commission. The Duquesne Light Company contributed 5,000,000 dols. towards the nuclear section of the plant; constructed, at their own expense, the turbine-generator section; and will operate the entire plant for the Atomic Energy Commission.

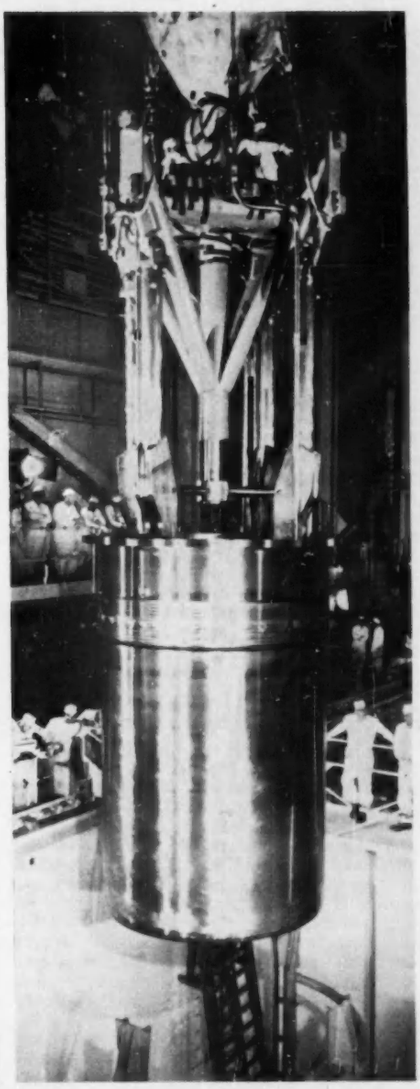


Fig. 4 Lowering the reactor core into the pressure vessel of the Shippingport pressurised-water reactor. It is the first American full-scale power reactor, rated at 60 (electrical) MW.

During the initial start-up test, the reactor operated at a power level of about 25 kW (heat). No electricity was generated. In the course of the next several weeks numerous tests will be made to determine the nuclear characteristics of the reactor and to establish the satisfactory operation of all reactor components. Following these tests, the power level of the reactor will be increased gradually. At full power the reactor plant will produce 60 MW of electricity which will flow into the system of the Duquesne Light Company.

The reactor core contains 14 tons of natural uranium in the form of a " blanket " surrounding some 165 lb. of highly enriched uranium. There are 32 enriched-uranium fuel elements, each with its own control rod, and 113 natural-uranium elements in the core. Figs. 4 and 5 show the 58 ton reactor core being lowered into the 33 ft. high reactor pressure vessel, which is installed underground. Fig. 6 shows two views of a full-size mock-up of the reactor.

General Notes

Contract for Rutherford Laboratory

The Governing Board of the National Institute for Research in Nuclear Science announce that W. E. Chivers and Sons Limited have been awarded a £1 million contract for the construction of the main buildings for the Institute's new Rutherford High Energy Laboratory on a site adjacent to the Atomic Energy Research Establishment at Harwell.

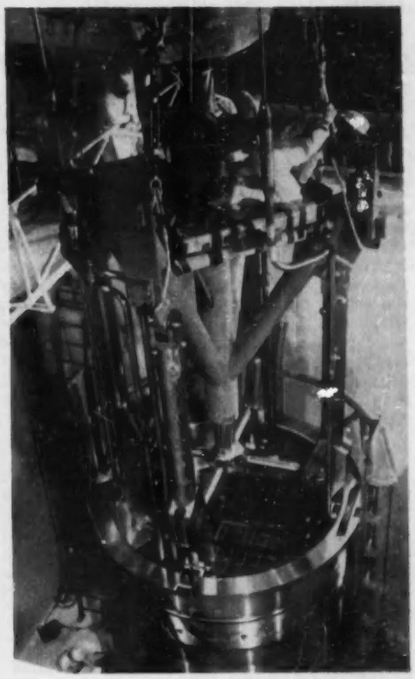


Fig. 5 Core of the Shippingport reactor, showing grid through which fuel elements and control rods are inserted. The reactor went critical last December 2, and began commercial operation on December 18.

Thermonuclear Information

The following is the text of a joint statement by Sir Edwin Plowden, chairman of the U.K.A.E.A., and Mr. Lewis L. Strauss, chairman of the U.S.A.E.C. " The United Kingdom and the United States have a close, co-operative arrangement for exchange of information on research in the field of controlled thermonuclear reactions. The agreement for co-operation between the two countries on civil uses of atomic

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energy has resulted in three conferences in 1957 for exchange of information on major phases of research into controlled thermonuclear reactions, one in Berkeley, California, in February, a second in Harwell, England, in June, and a third in Princeton, New Jersey, in October. As was announced at the conclusion of the Princeton meeting, temperatures have been reached in controlled thermonuclear experiments in the two countries that suggest the achievement of neutrons from thermonuclear reactions, but more experimental work will be necessary to establish this as a fact. Progress in the various experimental approaches to controlled thermonuclear reactions both in terms of negative findings and positive findings, is promptly communicated between the two nations. Thus the United States benefits from the research results of the approaches being taken by the British and the results of the work on the half-dozen or so approaches in the United States benefit the United Kingdom.

There have been statements in the news recently that have made unfortunate and confusing comparative observations about the United Kingdom and the United States programmes in this field. Such observations are not only inappropriate in co-operative programmes of this kind, but are seriously misleading."

Experiments with ZETA

Details of promising results obtained from experiments on ZETA are expected to be published early in the New Year. This was indicated last week by Mr. R. A. Butler, Leader of the House of Commons. ZETA is an apparatus at Harwell for work on controlled thermonuclear fusion reactions and was discussed in Atomic Review last August 2. Mr. R. Maudling, Paymaster-General, stated that discharges through heavy-hydrogen gas had yielded very high temperatures. Experiments have been in progress to identify the source of accompanying neutron emission, which may be thermonuclear in origin. There are signs of considerable excitement about the results so far obtained. Temperatures of at least 5 million deg. C., which should be sufficient to give detectable fusion reactions, have been reported.

Plasma Instabilities

Thermonuclear reactions are likely to illustrate the practical results that sometimes follow from theoretical physics. The relevance of gas-discharge experiments to thermonuclear reactions is well known. It can be shown that there exist stable configurations of a cylindrical gas discharge, in which there is a trapped axial field, if the discharge is in a conducting tube. The particular stable configuration obtained is one in which the axial field is concentrated inside the plasma and the current is carried on the plasma surface. No such stability exists when the current is uniformly distributed throughout the plasma and the magnetic field in the vacuum exceeds that in the plasma. It seems likely that there are more general stable configurations in which the current is mainly carried near the plasma surface and the trapped magnetic field has its maximum value near the centre. (R. J. Tayler: AERE T/R 2262.)

Lithium in Cornish China Clay

Experimental work in connection with the flotation of lithium-bearing micas from waste dumps of Cornish china clay necessitated the determination of lithium in micaceous and siliceous materials over the range 0·05 per cent. to 0·4 per cent. with a precision of ± 5 per cent. of the lithium content. Two possible methods of approach have been examined and both gave satisfactory results. One method involved dilution of the sample with a suitable spectrographic buffer and internal standard, followed by excitation in a direct-current arc. The alternative method utilised flame photometry after preliminary solution of the sample in mixed acids. (E. H. Henderson, M. J. Owers and M. S. W. Webb: AERE C/R 2137.)

Helium3 Enrichment

An atmospheric helium thermal diffusion plant, capable of producing 2 c.c. N.T.P. of helium3 per week at concentrations up to 10 per cent. He^3/He, has been operating for several years. It consisted of three metal columns, two of them identical coaxial-tube columns and the other a hot-wire column. Experiments have been described which were performed on the individual columns to determine the transport coefficient, H, and the variation of the equilibrium separation factor with pressure. The onset of turbulence in the coaxial-tube column was also investigated. The values of the column constants obtained are compared with theory and with the results of other workers. (R. W. Bowring: AERE GP/R 2058 part 1.)

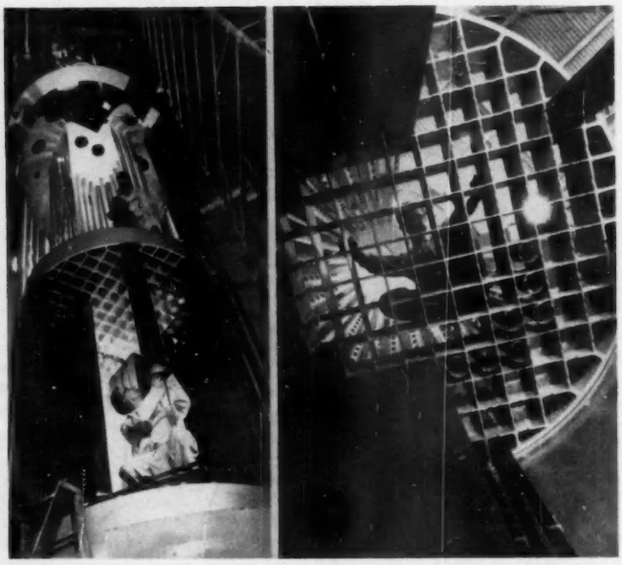


Fig. 6 Views of a mock-up of the Shippingport reactor illustrating the arrangement of the reactor core. On the left a wooden model fuel element is being placed in position. Through the grid plate in the illustration on the right can be seen a number of shrouds for guiding the control rods.

Not Occidental

The past year has had its ominous moments. The publication by Professor S. C. Harland of a warning that radiation might give rise to new and unwelcome pathogenic organisms, and the almost simultaneous outbreak of an unusual form of influenza in the East may of course have been a mere coincidence—or Asian fluke.

* * *

In the article "Suction on Single Slope Roofs," by Mr. J. D. Haddon, M.B.E., in our issue of December 6 (page 732), we stated, in reference to light-alloy structures, that: "A roof, 40 ft. by 40 ft. and weighing 5 lb. per sq. ft., on a rectangular shed may, in a 95 m.p.h. gale, have to withstand a net vertical lift of about 20 tons, whatever its slope." It should be noted that this statement applied specifically to prismatic roofs.

Production

MORE TRACTION MOTORS

From the early days of electric traction the General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, have been prominent manufacturers of traction equipment. To keep abreast of developments in railway electrification, both in this country and abroad, the company have opened a new works at Dudley Port, Tipton, Staffordshire, solely for the manufacture of motors and generators for railway rolling stock. The factory, which is within easy reach of the company's main engineering works at Witton, Birmingham, from which it draws certain of its components, has a floor area of 80,000 sq. ft. It is capable of producing £1 million worth of traction equipment a year at present, and double that figure in the near future.

Dudley Port works are a self-contained unit, with fully-equipped machine, assembly and test shops, and the layout is designed for batch production by flow-line methods. Raw materials are delivered by road to a stores section o the works, and from this point they pass to the machining, commutator and core-building, and armature winding sections. A short sideways movement then brings the components together in the assembly and despatch department, one section of which is fenced off and equipped for testing purposes.

Electrical stampings are supplied by the Witton works, and all other parts are machined or built up at Dudley Port. The machine tools include a planer and a plano-miller, vertical and horizontal borers, automatic, capstan, turret, copying and centre lathes, radial drillers, slotters and shapers. Two 100-ton hydraulic presses are installed in the core-building section. Equipment in the armature-winding bay includes electronic balancing and fault-testing machines, which were specially designed and built in the company's Witton Laboratories.

Special attention has been given to the question of materials handling, and overhead travelling cranes are provided where necessary, supplemented by individual hoist blocks and jib cranes. For handling components in the machining bay there is a hoist arrangement devised by the company to suit the machine layout. A channel structure is carried on fabricated brackets bolted to the main roof stanchions, so that it is over the line of machines, and running on this structure are several carriages. Each carriage has a length of monorail carrying a 5 cwt. electric hoist block. Every machine tool is thus not only provided with adequate lifting facilities, but it is possible to transfer components from any machine in the line to any other.

TESTING

The test section is equipped to deal with a factory output of at least 50 main driving motors per week, together with the ancillary motor generator and exhauster sets. It can handle

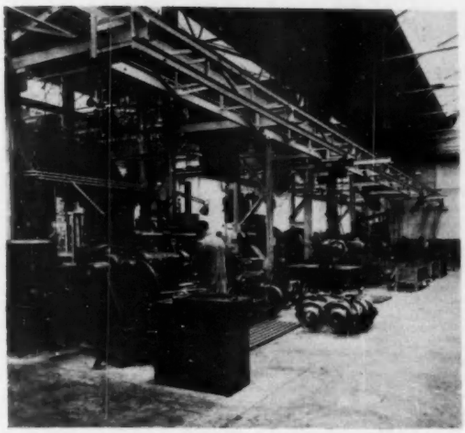


Fig. 1 (left) Particular attention has been paid to materials handling at the new G.E.C. traction motor works. Individual electric hoists in the machine shop serve any machine in the line.

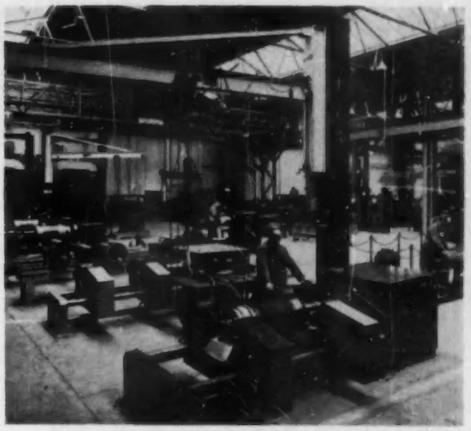


Fig. 2 (right) For dynamic balancing and testing armatures, the company designed and built their own electronic machines.

main generators up to 800 kW for Diesel-electric vehicles. There are four main test beds, each with its own test panel and forced-ventilation air supply. Each test panel has all the necessary controls and instruments, and only one operator is needed for running a test. Similar test beds and controls are provided for motor-generator sets and exhauster or compressor motors.

Power is supplied by four motor-generator sets housed in the adjoining substation. Each consists of a motor direct-coupled to two generators, one of which gives a high-voltage supply, while the other generates a heavy current at a low voltage. Back-to-back methods of testing are used; only the losses have to be supplied, and as a consequence the peak demand does not exceed 500 kW.

POWER, LIGHT AND HEAT

Power for the factory is taken from the Midlands Electricity Board's 7,000 volt, 2-phase, 3-wire system, and converted in two transformers to 440 volts, 3-phase, 4-wire. One transformer, rated at 6,000 kVA, supplies the works; the other, rated at 800 kVA, is for the test equipment.

Lighting, which imposes a total load of 55 kW, is by 400 W high-pressure mercury-vapour fluorescent lamps, giving an intensity of 12 to 15 lumens at the working plane.

Heating and ventilating equipment is installed to maintain a temperature of 65 deg. F. in the works with an outside temperature of 32 deg. F., while providing two air-changes per hour. The total heating load is 5 million B.Th.U. per hour. Unit heaters of the projection type, supplied with high-pressure hot water from two oil-fired boilers are used in the works, and convector heaters are installed in the offices. The temperature of the circulating water is 345 deg. F.

CONTINUOUS WALL CHART

To overcome a difficulty which occurs when the period covered by a fixed wall chart comes to an end as, for instance, at the end of the year—a difficulty which has sometimes been met in the past by adding another chart or portion of a chart to the existing one—Adapta Charts Limited, 129 Hammersmith-road, London, W.14, have added the Rotadate chart to their Movigraph range. This enables a process or state to be charted over a current period. The system is made up of a number of panels which fit into two horizontal channelled wooden sections screwed to a wall. Panels can be removed or inserted in a matter of seconds. When the period covered by the panel at the extreme left has expired, that panel is removed and the remainder pushed towards the left, leaving a gap for a fresh panel on the right to cover the next period. The flow-line markers are attached in such a way that they adjust themselves automatically, and that portion of the chart which holds the title frames is separate and permanently fixed.

REFRIGERATOR COMPRESSORS

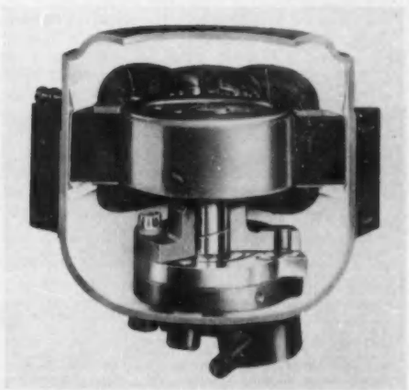
On November 29, the Frigidaire Division of General Motors Limited completed the manufacture of their 1,000,000th MeterMiser sealed rotary compressor unit made at the factory in Stag-lane, Kingsbury, London, N.W.9. Production of the units began on November 22, 1948, and at that time the rate was approximately 300 a day; it has now risen to something approaching 1,000. The basic process, however, has not been altered.

The MeterMiser is a rotary compressor unit using an eccentric rotor, and requires accurate machining if it is to operate efficiently. In particular, accurate control of the surface finish of the parts is needed, since the unit is finally hermetically sealed in a steel case, rendering repairs virtually impossible. The unit is made in several sizes according to the capacity of the refrigerator. Naturally, since very fine tolerances are involved, cleanliness is extremely important in the final assembly and this is therefore carried out in an atmosphere-controlled room where all employees wear lint-free clothing.

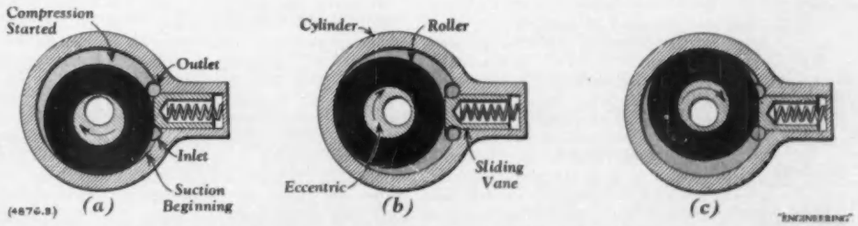
The three moving parts are the roller, the vane and the eccentric shaft (which last is a force-fit in the rotor of the driving motor) and all of these are ground and polished to a specified tolerance of $\pm$ 0·0001 in. Corresponding to the three moving parts are three fixed parts, the upper bearing plate, the cylinder plate and the lower bearing plate. These are made of high grade cast iron, whereas the moving portions are of steel, hardened and tempered. Machining accuracies on the fixed parts are, of course, of the same order as those of the moving parts. The surface finish of the different parts varies slightly, but all except the slot in which the vane slides are ground and lapped to a surface roughness of less than 7 millionths of an inch r.m.s. The slot faces have a finish of about 50 millionths r.m.s., since a smoother surface induced " wringing " with the vane and so absorbed more power. All items are checked at each stage of manufacture, and a final check is made on them before assembly. Periodical checks of the gauges themselves, and of a random number of parts, are made by perambulating inspectors against the standards kept in the test room. The final check of all parts is carried out in the air conditioned room, immediately prior to assembly.

The stators and rotors are both made by A.C. Delco and are shipped to Stag-lane in hermetically sealed containers. In spite of this precaution, they are again cleaned and dried before being assembled in the steel shell.

In addition to the MeterMiser rotary compressors, which are mainly incorporated in domestic sizes of refrigerators, larger reciprocating units are made at Stag-lane. This side of the business has increased greatly since the plant at Dayton, Ohio, concentrated exclusively on domestic models. Stag-lane is now, therefore, supplying these commercial sizes virtually to the whole world.



The MeterMiser is a hermetically sealed rotary compressor unit using an eccentric rotor. Extreme accuracy in size and surface finish of the working parts is required for efficient operation.



Three stages in the action of the compressor. The eccentric drives the roller against the walls of the cylinder, forcing a pocket of gas round at the same time. The sliding vane forms a seal between inlet and outlet.

NOTICES OF MEETINGS

British Institution of Radio Engineers

GLASGOW
"Electronic Calculator Circuitry," by F. Baillie. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Jan. 9, 7 p.m.
NEWCASTLE-UPON-TYNE
"The Earth Satellite Project," by P. H. Tanner. North Eastern Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Wed., Jan. 8, 6 p.m.
WOLVERHAMPTON
"Instrumentation of Space Vehicles," by N. R. Nicoll. West Midlands Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Jan. 8, 7.15 p.m.

British Interplanetary Society

LONDON
"High Altitude Research During the International Geophysical Year," by Dr. R. F. L. Boyd. Caxton Hall, off Victoria-street, S.W.1. Sat., Jan. 4, 6 p.m.

Chemical Society

EDINBURGH
Jubilee Memorial Lecture on "The Pattern of Research in the Electrical Industry," by Dr. H. K. Cameron. Edinburgh Branch. Royal Society of Edinburgh, 24 George-street, Edinburgh. Thurs., Jan. 9, 7.30 p.m.

Combustion Engineering Association

LONDON
Brains Trust Meeting on "Coal Price Structure." Southern Region. St. Ermin's Hotel, Caxton-street, S.W.1. Wed., Jan. 8. 2.30 p.m.

Helicopter Association

LONDON
"Boost Systems for Helicopter Gas Turbines," by Dr. A. W. Morley. Royal Aeronautical Society, 4 Hamilton-place, W.1. Fri., Jan. 10, 6 p.m.

Illuminating Engineering Society

LONDON
"Lighting of Aircraft Flight Decks," by J. W. Strange and B. Stevens. Federation of British Industries, 21 Tothill-street, S.W.1. Tues., Jan. 14, 6 p.m.
CARDIFF
"Lighting for Photography," by R. W. Unwin. Cardiff Centre. Offices of the South Wales Electricity Board, The Hayes, Cardiff. Thurs., Jan. 9, 7.30 p.m.
EDINBURGH
"The Sales Engineer's Approach to Lighting," by W. J. Burland. Edinburgh Centre. Y.M.C.A., 14 South St. Andrew-street, Edinburgh. Wed., Jan. 8, 6.15 p.m.
NOTTINGHAM
"Lighting from the Contractor's Point of View," by N. C. Slater. Nottingham Centre. Offices of the East Midlands Electricity Board, Smithy-row, Nottingham. Thurs., Jan. 2, 6 p.m.*

Incorporated Plant Engineers

LONDON
"A Practical Survey of Automatic Combustion Regulation on Industrial Boilers," by W. R. L. Kent. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Tues., Jan. 7, 7 p.m.*
BRISTOL
"Education in Industry," by E. G. Sterland. Western Branch. Grand Hotel, Bristol. Wed., Jan. 8, 7.15 p.m.
EDINBURGH
"Construction of a Welded Pipe Line," by R. Downie. Edinburgh Branch. 25 Charlotte-square, Edinburgh. Tues., Jan. 7, 7 p.m.
LEICESTER
"Smoke Abatement," by S. N. Duguid. Leicester Branch. Bell Hotel, Leicester. Wed., Jan. 1, 7 p.m.
NOTTINGHAM
"The Petroleum Industry," by J. Collins. East Midlands Branch. County Hotel, Theatre-square, Nottingham. Wed., Jan. 8, 7 p.m.
PETERBOROUGH
"Production and Maintenance in an Automobile Factory," by K. B. O'Kell. Peterborough Branch. White Lion Hotel, Church-street, Peterborough. Tues., Jan. 7, 7.30 p.m.

Institute of Fuel

LONDON
"The Influence of the Adsorption of Frothing Agent on the Percentage Recovery of Coal from Flotation Pulps," by Dr. A. Jowett. Institution of Civil Engineers, Great George-street, S.W.1. Wed., Jan. 8, 5.30 p.m.*
NEWCASTLE-UPON-TYNE
"Oil Fuel at Home," by K. S. Brett. North Eastern Section. King's College, Newcastle-upon-Tyne. Mon., Jan. 6, 6.30 p.m.
PORT TALBOT
"Planning Construction and Problems Associated with Berkeley and Dounreay Power Stations," by P. K. Richards. South Wales Section. Canteen Hall, Abbey Works, Steel Company of Wales Ltd., Port Talbot. Wed., Jan. 8, 6 p.m.

Institute of Metals

BIRMINGHAM
"Production of Rods and Shapes in Copper and Its Alloys," by Dr. N. Swindells. Birmingham Local Section. College of Technology, Gosta Green, Birmingham. Thurs., Jan. 9, 6.30 p.m.
OXFORD
Junior Members' Evening. Discussion on "Seeing Dislocations." Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Jan. 7, 7 p.m.
SWANSEA
"Electron Microscopy," by Dr. J. W. Menter. South Wales Local Section. Department of Metallurgy, University College, Singleton Park, Swansea. Tues., Jan. 14, 6.30 p.m.*

Institute of Petroleum

LONDON
"Lubrication Problems Arising from Railway Traction Modernisation," by W. B. Broadbent and G. A. Dickins. Wed., Jan. 1, 5.30 p.m.*

Institute of Physics

LONDON
"Physical Research in the Research Group of the Atomic Energy Authority," by Dr. B. F. J. Schonland. London and Home Counties Branch. Wed., Jan. 15, 6 p.m.*
LIVERPOOL
"Radio Astronomy," by Dr. H. P. Palmer. Liverpool and North Wales Branch. Department of Electrical Engineering, The University, Liverpool. Fri., Jan. 3, 7 p.m.*
MANCHESTER
"Contact Electrification," by Dr. P. S. H. Henry. Manchester Branch. Bragg Lecture Theatre, The University, Manchester. Fri., Jan. 10, 6.45 p.m.

Institute of Refrigeration

LONDON
"Properties, Handling and Storage of Modern Refrigerants," by W. F. Bews. Junior Institution of Engineers, Pepys House, 14 Rochester-row, S.W.1. Thurs., Jan. 2, 5.30 p.m.*

Institution of Civil Engineers

LONDON
"No. 1 Berth, Tilbury Dock, Port of London Authority," by C. Peel, A. J. Carmichael and R. F. J. Smeardon. Tues., Jan. 7, 5.30 p.m.*
Dugald Clerk Lecture on "Lifting Equipment," by W. R. Hockaday. Wed., Jan. 8, 6.30 p.m.*
BIRMINGHAM
"Engineering Research at the Building Research Station," by Dr. F. G. Thomas. Midlands Association. James Watt Memorial Institute, Great Charles-street, Birmingham 3. Thurs., Jan. 9, 6 p.m.
EDINBURGH
"The Engineer's Influence on Town Planning," by Alex. T. McIndoe. Edinburgh and East of Scotland Association. North British Hotel, Edinburgh. Wed., Jan. 8, 6 p.m.
NOTTINGHAM
"A New Approach to Building," by D. E. E. Gibson. East Midlands Association. College of Arts and Crafts, Waverley-street, Nottingham. Wed., Jan. 8, 6.15 p.m.

Institution of Electrical Engineers

LONDON
"The Breakdown of Transformer Oil under Impulse Voltages," by Dr. R. Hancox and Dr. H. Tropper. Measurement and Supply Sections. Tues., Jan. 7, 5.30 p.m.*
"Development of Variable-Speed High-Power Drives for Large Wind Tunnels," and "A Variable-Frequency Power Installation for Large Wind-Tunnel Drives," by P. McKearney, L. S. Drake and E. G. Mallalieu; "Speed Control of Large Wind Tunnels, with Particular Reference to the R.A.E. 8 ft. by 8 ft. High-Speed Wind Tunnel," by L. S. Drake, J. H. Fox and G. H. A. Gunnell; and "Data-Setting and Electrical Control Gear for the Flexible Nozzle and Diffuser of a High-Speed Wind Tunnel," by C. R. Dunham. Thurs., Jan. 9, 5.30 p.m.*
Address by the President, T. E. Goldup. London Graduate and Student Section. Mon., Jan. 6, 6.30 p.m.*
BIRMINGHAM
"Electrical Equipment for Rectifier Locomotives," by H. Calverley, E. A. K. Jarvis and E. Williams. South Midland Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Mon., Jan. 6, 6 p.m.*
FARNBOROUGH
"Colour Television," by C. J. Stubbington. Southern Centre. R.A.E. Technical College, Farnborough. Wed., Jan. 8, 6.30 p.m.
LEEDS
Various short papers on "Transistors," by C. Adamson and L. M. Wedephol. North Midland Centre. Offices of the Yorkshire Electricity Board, 1 Whitehall-road, Leeds. Tues., Jan. 7, 6.30 p.m.
LIVERPOOL
"British Columbia to Vancouver Island 138 kV Submarine Power Cable," by Dr. T. Ingledow and others. Mersey and North Wales Centre. Royal Institute, Colquitt-street, Liverpool. Mon., Jan. 6, 6.30 p.m.

Institution of Heating and Ventilating Engineers

LONDON
"Survey of Methods of Pressurisation for Medium and High-Pressure Hot-Water Systems," by J. R. Kell. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Thurs., Jan. 9, 6 p.m.*
NEWCASTLE-UPON-TYNE
"Air Filtration: Why and How," by G. H. Vokes. North East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Jan. 7, 6.30 p.m.

Institution of Highway Engineers

NORWICH
"Steel: Modern Applications of Rolled Sections," by F. G. Ward. East Anglia Branch. Assembly House, Norwich. Tues., Jan. 7, 6.30 p.m.

Institution of Mechanical Engineers

LONDON
"Design and Development of Four Lightweight High-Speed Marine Gas Turbines for Electric Generator Drive," by A. W. Pope; and "Developments in Methods of Measuring Stresses in Compressor and Turbine Blades on Test Bed and in Flight," by D. A. Drew. Meeting in conjunction with the Internal Combustion Engine Group. Fri., Jan. 10, 6 p.m.*
LOUGHBOROUGH
Annual General Meeting. "Numbers, Statistics and Computers in the Engineering Industry," by H. McGregor Ross. East Midlands Branch. Loughborough College of Technology, Greenclose-lane, Loughborough. Wed., Jan. 8, 7 p.m.
LUTON
"Pneumatic Suspensions for Motor Vehicles," by J. Sainsbury. Luton A.D. Centre. Town Hall, Luton. Wed., Jan. 8, 7.30 p.m.

Institution of Naval Architects

LONDON
Amos Ayre Lecture. "The Evolution of the Cargo Ship During the last 35 Years and Some Thoughts on the Years to Come," by Dr. J. Ramsay Gebbie. Thurs., Jan. 9, 4.45 p.m.*

Institution of Production Engineers

CHATHAM
"Pneumatic Circuiting," by H. C. Orchard. Rochester Section. Sun Hotel, Chatham. Thurs., Jan. 9, 7.30 p.m.
LEICESTER
"The Use of Plastics in Industry," by B. E. Terry. Leicester Section. Grand Hotel, Leicester. Thurs., Jan. 9, 7 p.m.
LIVERPOOL
"Inspection as an Aid to Production," by W. Maiden. Liverpool Section. Exchange Hotel, Tithebarn-street, Liverpool 2. Wed., Jan. 8, 7.30 p.m.
STAINES
"Practical Approach to Engineering Fine Surfaces," by D. B. Ebsworth. Reading Section. Social Club, Petters Ltd., Staines. Thurs., Jan. 9, 7.30 p.m.

Institution of Structural Engineers

LONDON
"The Calculation of Bending and Torsional Effects in Girders," by J. S. Terrington. Thurs., Jan. 9, 6 p.m.*
BRISTOL
"Construction of a Prestressed-Concrete Circular Tank," by G. B. Smedley. Western Counties Branch. University Engineering Laboratories, The University, Bristol. Fri., Jan. 3, 6 p.m.*
MANCHESTER
"Shrinkage in Soils," by E. Ll. Morgan. Lancashire and Cheshire Branch. College of Science and Technology, Manchester. Tues., Jan. 7, 6.30 p.m.*

Junior Institution of Engineers

LONDON
Film Evening. Fri., Jan. 3, 7 p.m.*
"Brewing and Distilling," by T. F. Luck. Fri., Jan. 10, 7 p.m.*

Leeds Metallurgical Society

LEEDS
"Corrosion Problems and Water Treatment in Power Stations," by R. W. Wolforth. Chemistry Wing, The University, Leeds 2. Thurs., Jan. 9, 7.15 p.m.

Newcomen Society

LONDON
"Travel Diaries of Swedish Engineers of the Eighteenth Century as Sources of Technological History," by Michael W. Flinn. Wed., Jan. 8, 5.30 p.m.

North East Coast Institution of Engineers and Shipbuilders

NEWCASTLE-UPON-TYNE
"University Education in Marine Engineering," by Professor G. H. Chambers. Mining Institute, Newcastle-upon-Tyne. Fri., Jan. 10, 6.15 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Annual General Meeting of the Methods of Analysis Group, and address by the new chairman of the Group. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Jan. 7, 7 p.m.

Society of Chemical Industry

LONDON
"Stress Corrosion Cracking," by T. P. Hoar and J. C. Hines. Corrosion Group. Wed., Jan. 15, 6.30 p.m.

Society of Instrument Technology

LONDON
"Design of Cascade Control Systems," by R. L. Day. Control Section. Manson House, 26 Portland-place, W.1. Thurs., Jan. 9, 7 p.m.
CHELTENHAM
Discussion on "Nickel Alloys for Instrument Production." Cheltenham Section. The Rotunda, Cheltenham. Tues., Jan. 7, 7.30 p.m.
FAWLEY
"Instruments Applied to Nuclear Power," by K. R. Sandiford. Fawley Section. Copthorne House, Fawley, Hants. Fri., Jan. 3, 7 p.m.

South Wales Institute of Engineers

CARDIFF
"Some Aspects of the Design and Erection of Skyscraper Buildings," by L. G. Johnson. Thurs., Jan. 9, 6 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
British Interplanetary Society, 12 Bessborough-gardens, London, S.W.1. (TATe Gallery 9371.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Combustion Engineering Association, 6 Duke-street, St. James's, London, S.W.1. (WHItehall 5536.)
Helicopter Association of Great Britain, 4 The Sanctuary, London, S.W.1. (ABBey 5160.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Petroleum, 61 Cavendish-street, London, W.1. (LANgham 2250.)
Institute of Physics, 47 Belgrave-square, London, S.W.1. (BELgravia 6111.)
Institute of Refrigeration, New Bridge Street House, New Bridge-street, London, E.C.4. (CENtral 4694.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Highway Engineers, 47 Victoria-street, London, S.W.1. (ABBey 3891.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Leeds Metallurgical Society. Apply to Dr. P. Feltham, The University, Leeds.
Newcomen Society, Science Museum, Exhibition-road, London, S.W.7. (KENsington 1793.)
North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne 1. (Newcastle 20289.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield 10. (Sheffield 62144.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
South Wales Institute of Engineers, Park-place, Cardiff. (Cardiff 23296.)

In Parliament

SELLING TO CANADA

In one of the last sittings before the Christmas recess, some time was devoted to the discussion of questions on trade and commercial matters. Mr. E. S. T. Johnson (Conservative) drew attention to the view expressed by members of the Canadian Trade Mission that British goods were still the best in the world and that it would be in the best interests of Canada to purchase them, but, at the same time, that this country sadly lagged behind in making the facts known to her potential customers.

This particular subject arose out of a request by Mr. Ellis Smith (Labour) to Sir David Eccles, the President of the Board of Trade, that he should arrange for exhibits of nuclear-energy plant to be shown at the forthcoming British Fair of Industry and Commerce at Manchester. He also urged that, in view of the need to stimulate exports, Sir David should do all he could to encourage exporting industries to take part in the fair. Sir David said that it was for the Atomic Energy Authority and the manufacturers of nuclear-energy plant to decide whether or not they should exhibit. His Department had given publicity to the fair in its *Journal* and he would certainly consider a suggestion that had been put forward that he should write to the Lord Mayor of Manchester commending the fair. (Particulars of this fair are given in " Exhibitions and Conferences " on page 812.)

CO-OPERATIVE SALES TO EUROPE

Later, at the same sitting, Sir David was pressed by Mr. James Harrison (Labour) to issue an illustrated booklet explaining the project for a free market area in Europe and containing suggestions for overcoming possible difficulties by appropriate business reorganisation and changed techniques. Mr. Harrison pointed out that in the Midlands, especially in the Nottingham and Birmingham area, many of this country's most important industries were organised in very small units, with rather limited, and sometimes primitive, selling organisations. He felt that it would help considerably if Sir David would use his good offices to try to create some form of co-operative or selling organisations among these many small firms.

Sir David told the House that the proposals for a Free Trade Area in Europe were discussed in a White Paper published in February last and in an official explanatory booklet published in May. The first tariff reductions among the members of the European Economic Community will take place a year after the Treaty of Rome comes into effect. The full implementation of the treaty would be a gradual process spread over 12 to 15 years. The Government hoped that a wider Free Trade Area would begin to operate at the same time as the European Economic Community. He was prepared to examine the idea of co-operative selling.

BRITISH STANDARDS INSTITUTION

Suggestions that the work of the Consumer Advisory Council of the British Standards Institution is being impeded by the lack of co-operation of manufacturers were made by Miss Elaine Burton (Labour), who affirmed that, since January, 1955, none of the industries asked by the Advisory Council to participate in Kitemark schemes had agreed.

Miss Burton stated that the manufacturers of children's footwear had definitely declined to co-operate with the Council and considered that a committee should be set up to inquire into the advisability of granting additional powers to the B.S.I. What was the use of the Government giving the Council £10,000 to do the job, and then not giving them the authority to get on with it? Sir David agreed that the Council was disappointed with the response of some manufacturers to its proposals, but felt that the work which the B.S.I. carried out for the domestic consumer was certainly not impeded by manufacturers generally. The Council's first task was to make the public aware of what was meant by the Kitemark schemes. His impression was that the public did not fully understand and that when they did, manufacturers would pay attention. He saw no case for considering the grant of statutory powers to the Institution.

TRANSPORT AIRCRAFT

Information respecting the activities of the Transport Aircraft Requirement Committee was given by Mr. Aubrey Jones, the Minister of Supply. He said that the committee was an advisory body and that its terms of reference were to keep under review the programme for the development and production of transport aircraft in the light of civil and military requirements, actual and potential, and of developments in other countries, and to make recommendations.

Representatives of the Admiralty, Treasury, Air Ministry, Ministry of Supply, Ministry of Transport and Civil Aviation, British European Airways, British Overseas Airways Corporation, and the British Independent Air Transport Association, served on the committee. The committee had considered a number of requirements, including a medium/long-range jet aircraft for B.O.A.C., which is to be met by the purchase of 35 Vickers VC10 aircraft; a medium/short-range jet aircraft for B.E.A., on which he hoped that an early decision would be announced; a supersonic civil transport aircraft, on which a research study was being made; the future advancement of projects at present forming part of the civil aircraft development programme, namely, the Britannia aircraft, the Rotodyne helicopter and the Orion aero-engine; and an aircraft and an engine project, which were not being pursued.

Mr. Aubrey Jones told Air-Commodore Sir Arthur Harvey (Conservative) that the committee was at present giving consideration to possible requirements for a long-range freighter. In addition, it was considering a programme of research and development, and was conducting a review of all possible transport requirements of the Services, the Air Corporations, and the independent air companies within the next 10 to 15 years, and of all projects for the development of transport aircraft which members of the aircraft industry wish to bring forward. The co-operation of the Society of British Aircraft Constructors had been sought to ensure that no suitable projects were overlooked.

MANAGEMENT AT H.M. DOCKYARDS

A brief discussion, initiated by Mr. Austen Albu (Labour), took place on management problems at H.M. Dockyards. Mr. T. G. D. Galbraith, the Civil Lord of the Admiralty, stated that no changes had been made in the arrangements for personnel management at the dockyards during the past five years. At headquarters, a civilian officer with wide experience of labour relations was appointed in 1954 as personnel officer. His duties had recently been widened and he now acted as assistant director of dockyards (personnel).

In respect to changes in the management structure, an experimental appointment of a senior civilian officer as deputy superintendent (industrial) was made at Chatham in 1953. An additional deputy manager had been appointed in each of the constructive, engineering, and electrical departments at the Portsmouth, Devonport and Chatham dockyards. Planning groups were now being introduced at the main home dockyards and method study officers were being appointed. A team of senior officers was examining the scope for work measurement in the yards. Management structure of the dockyards was one of the matters on which the committee under the chairmanship of Sir Barclay Nihill had recently reported.

Another aspect raised by Mr. Albu was the extent to which arrangements were at present made for the training of senior and junior supervisory staffs in management methods. Mr. Galbraith told him that an assistant director, management techniques, had been appointed at headquarters in 1954. Management training centres were in operation at Portsmouth, Devonport and Chatham. They provided two-week courses for chargement and job-relations training for all managing and supervising officers. The Portsmouth centre provided, in addition, four-week courses for inspectors from all yards. A variety of residential conferences of up to three weeks' duration was organised for grades from senior inspector to manager. Selected officers were sent to external management-training courses. It was planned to set up in the near future a centre to provide training in the techniques of methods study and planning.

Artificer Apprentices

A plea was made by the Rev. Reginald Sorensen (Labour) that the Admiralty should reconsider the arrangements whereby artificer apprentices have to engage to serve in the Royal Navy for 12 years from the age of 18. He was informed by Mr. Christopher Soames, Parliamentary Secretary to the Admiralty, that the Lords Commissioners periodically reviewed the position, but that no change was contemplated.

Researches on Solar Energy

Sir Wavell Wakefield (Conservative) questioned the Secretary of State for the Colonies about the utilisation of solar heat, and asked why, since some parts of the British Commonwealth occupied geographical positions exceptionally favourable for the use of the sun's energy, the United Kingdom was lagging so far behind the United States in this respect. Mr. Alan Lennox-Boyd replied that some work of potential value to colonial territories had been conducted in this country. Several Government scientific institutions, including the Tropical Products Institute, kept in touch with international developments in this field and had given colonial territories advice about them.

Scarce Minerals in Nyasaland

To what extent, Mr. Sydney Irving (Labour/Co-operative) asked the Secretary of State for the Colonies, had thorium, titanium and pyrochlore been found in Nyasaland; to which companies had prospecting licences been granted; and to what extent would those discoveries assist the country's economic development. Mr. John Profumo, the Under-Secretary of State, answered that it had been known for some time that all three minerals existed in Nyasaland. Occurrences so far located were being investigated. More detailed information was being sought by the Colonial Office.

Motor Car Exports to the United States

Exports of new motor cars to the United States during the first ten months of this year were valued at £31,400,000, according to information supplied by Sir David Eccles to Mr. Sorensen. The comparable figures for the previous five years, Sir David stated, had varied between £8,400,000 and £12,600,000. The motor manufacturers, therefore, had been very successful in this market and they were themselves the best judges of how to maintain sales' expansion.

Learning Russian

The Minister of Education was urged by Mr. Ernest Thornton (Labour) to encourage the study of the Russian language by science and technical students in universities and the higher technological institutes " in view of the now widely acknowledged status of Russian science and technology." Mr. J. Enoch Powell, the Financial Secretary to the Treasury, replied that it was for the universities themselves to arrange the curriculum of their courses. He was informed, however, that Russian was taught at most of the larger universities and that there were evening classes in Russian at a number of technical colleges, some of which were planning special courses in Russian for students of science and technology.

The Human Element

Who Pays for Horseplay?

A recent legal case, Hudson *v.* Ridge Company, Limited, has drawn attention once again to the liability for compensation when two men are working on the same job. A prank was played by one employee on another in a certain works leading to the latter breaking his wrist. The man brought a case against his employers and pleaded that it was the duty of employers to have reasonably safe plant and machinery and that to evolve a reasonably safe system of working it might be necessary to remove fellow workmen who indulged in horseplay. The new ground broken by this case is that it could be pleaded that having a stupid and irresponsible workman addicted to horseplay on the payroll, who was known to be such a person, constituted a potential source of injury to other people which should be removed.

The man has won his case. It seems to mean for industry at large that a man's ability to hold his job must be judged in part on his ability to avoid being a danger to his work mates. The law has come a long way from the days when an employer was considered not to be liable under any circumstances for damage done by one employee to another. The law has indeed come, for practical purposes, full circle and the employer is left in a somewhat vulnerable position. He is placed in a difficulty not only a regards the law but also as regards the trade unions. It is well nigh impossible for an employer to persuade a union that a certain workman must be dismissed because he is a potential danger to other union members. Equally, if employers were able to get away with this the principle is one which could lead to abuse. The original doctrine to common employment may have been unfair but the removal of injustice has created as many problems as it has solved.

Brooking No Interference

A swingeing attack on the intervention by Governments in the affairs of industry was delivered by Mr. Frank Cousins at a recent luncheon meeting of the American Chamber of Commerce. It was a statement of personal policy in the best tradition of militant trade unionism: the sooner Government leaders left the resolution of industrial problems to employers and trade unionists, " the better I, for one, will like it," and " it will be a sorry day when the trade-union movement took its direction from any government, whatever its political faith."

On the subject of restraint, Mr. Cousins said his own union were opposed to it if those enjoined to exercise it were the trade unions and no one else. He emphasised that the trade unions have rightly refused to recognise " a system that says that 'freedom for all' means all but the trade-union movement." He expressed concern at the development of an attitude that there was an inevitable conflict growing between the trade union movement and the Government. His own union were prepared to accept, in fact claim that they have accepted, their own " full measure " of responsibility. But this did not mean accepting blindly that anything the Government say is right, or that they have a monopoly of effective remedies for the country's economic troubles.

Even taking into account that this speech was to an American audience, it was more conciliatory and less destructive than it has been Mr. Cousins' practice to make.

Hans Begins to Hanker

News from Bonn suggests that the German Government are finding it increasingly difficult " to hold price and wage levels." It would appear that their defences against this kind of pressure are not much more effective than Mr. Macmillan's commands that prices should stand still. The 6 per cent. wage increase just granted to 2 to 3 million workers in the engineering, shipbuilding and related industries has added £55 million a year to industrial costs.

The difference between Britain and Germany lies perhaps in the greater ruthlessness the Germans expect (and get) from their governing bodies. If the miners try to pass on increased costs due to granting a wage rise they will find the German industry buys United States coal at a lower price, or heavy fuel oil (offered at DM 2 to DM3 per ton below the comparable price for coal). The Minister of Economics, Herr Guthermuth, thought such a situation would pave the way for the nationalisation of the mines—which might rescue his Government from an awkward position.

Whatever the German Government do to counteract wage pressures the fact remains that the cost of living has gone up 3·5 per cent. in the past twelve months, that German workers are paid less than most in Europe, and that Germany still exports more than is good for her economy. The odds are that the gap between British and German wages will narrow substantially in the New Year.

Musical Chairs

Little but criticism of the present methods used to select students for the universities resulted from the second session of the Home Universities Conference. The vice-chancellor of Liverpool University, Sir James Mountford, spoke of a situation of " deplorable chaos," of " fumbling uncertainties " and " administrative disaster." Speaking for the universities, Sir James explained that much of the trouble arose since it had become easier for school pupils to go to university. It had become normal for them to apply to many universities—an average of two, apart from Oxford or Cambridge. As a result, the deans found that the people they wanted had accepted places elsewhere, and therefore " had to fill up from the bottom of their list at the last minute "; the schools were harassed by countless requests from the universities for confidential reports on applicants and no one, least of all the university aspirants, really knew what had happened at the year's end.

Speaking for the schools, Mr. Robert Birley, headmaster of Eton, agreed with Sir James that the situation was chaotic. Sir James Mountford's suggestion that " the mad scramble which now takes place in late August " could be avoided if the examination for the G.C.E. were moved forward from July to the end of the Lent term, gained support from Mr. Birley, despite its drastic character. But change comes slowly and heretical suggestions such as a January start for the university term seldom survive the rarified atmosphere of such a conference.

Improper Conduct

Not to be outdone by the Electrical Trades Union, the A.E.U. or anyone else, the Oxford Union Society has had a special committee inquiring into " allegations of improper conduct by last term's president"' A special committee of three former presidents found that the gentleman concerned, Mr. Brian Walden, had in fact inspired a leak concerning the fitness of one of the candidates in the election for president, Mr. Rudolf D'Mello. The committee appear to have no doubt that Mr. Walden did provide an undergraduate journalist on the staff of *Isis*, Mr. Dennis Potter, with information about Mr. D'Mello which was " discreditable or supposedly so." But at this stage the unexpected took a hand, and Mr. Potter wrote an article on the misdeeds of Mr. Walden.

The committee of inquiry concluded that in this topsy turvy affair all parties were to blame, though Mr. D'Mello only by failing to gain election. Mr. Walden acted in a manner " that cannot be justified before a tribunal such as this." Mr. Potter may have thought it his duty to tell the University what a cad he considered Mr. Walden to be, but he did nonetheless mislead the latter, abused his confidence and in general " acted in an unfortunate manner." The sooner the affair is forgotten, the committee say, the better. But alas no one likes to be told he interfered with an election, whether Mr. Foulkes or Mr. Walden, and much will yet be heard upon it. The times when the candidate for Parliament relied on the best ale distributed to a sufficient number of the electors to sweep him into the House are gone. Perhaps it is as well. Though elections should not be taken with too great an air of solemnity, we should remember how delicately human civility is balanced on the fine distinctions of right conduct.

Critical Increment

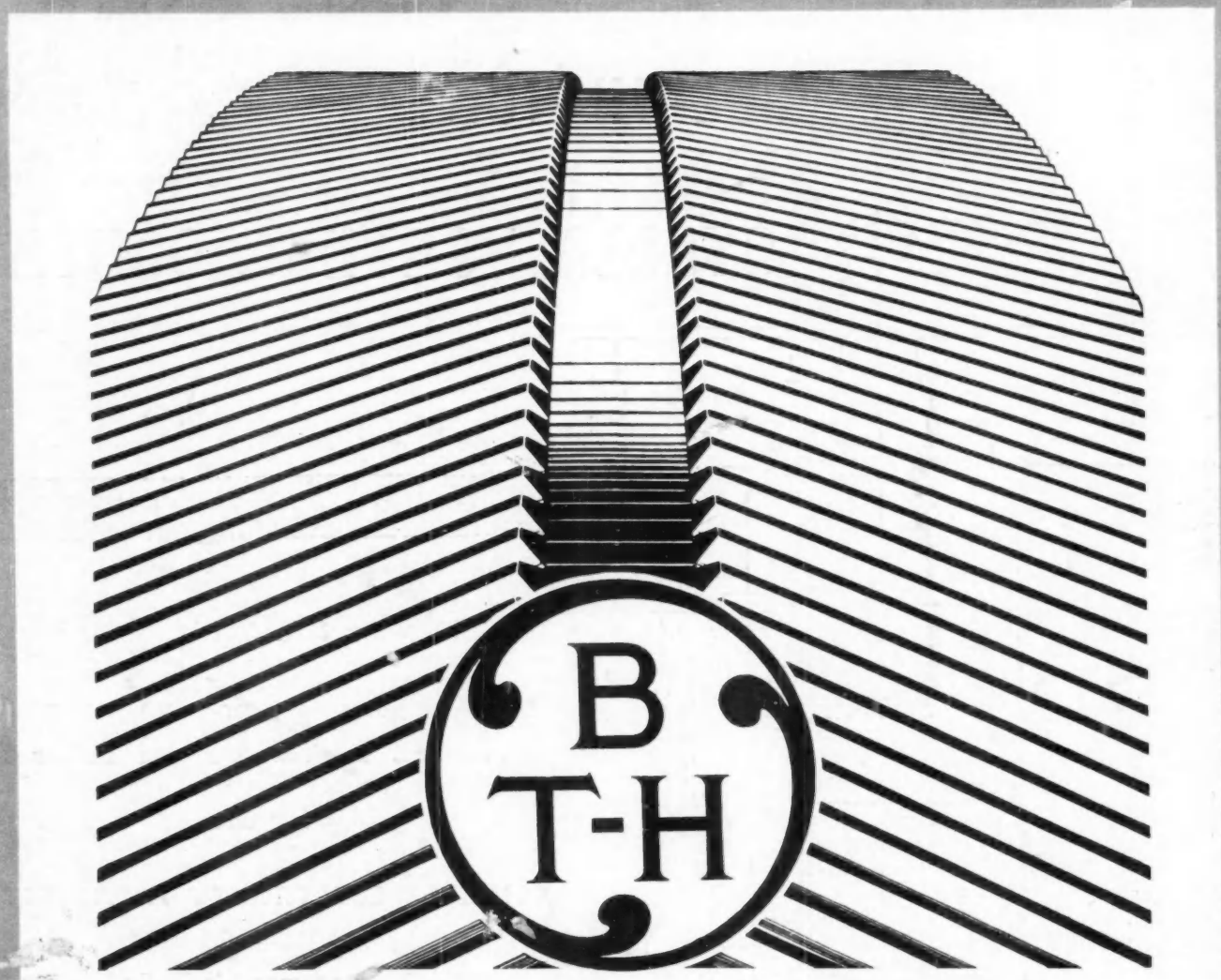
It was announced earlier this month that the cost-of-living index has increased by 1 per cent. between October and November. A good deal of the advance was due to a rise in rents and also to higher coal prices. The actual increase is only 0·6 per cent. but even if the more accurate figure is taken, the increase is unfortunate. It is going to be a cruel stroke of luck if the effects of the Rent Act produce a fortuitous increase more than sufficient to offset the decline in food prices.

Once the index advances more than 1 per cent. there will be a double effect on wage demands. The increase will harden the determination of union leaders to persist with their demand for higher wages because the cost of living is rising, thus providing the moderate element with a useful excuse for joining the militants. Secondly, it will bring new customers to the wage counter.

END OF THE 184TH VOLUME

ENGINEERING

An Illustrated Weekly Journal



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